SEPTEMBER • 1955

PETROLEUM REFINER

REFINING | PETROCHEMICALS | NATURAL GASOLINE

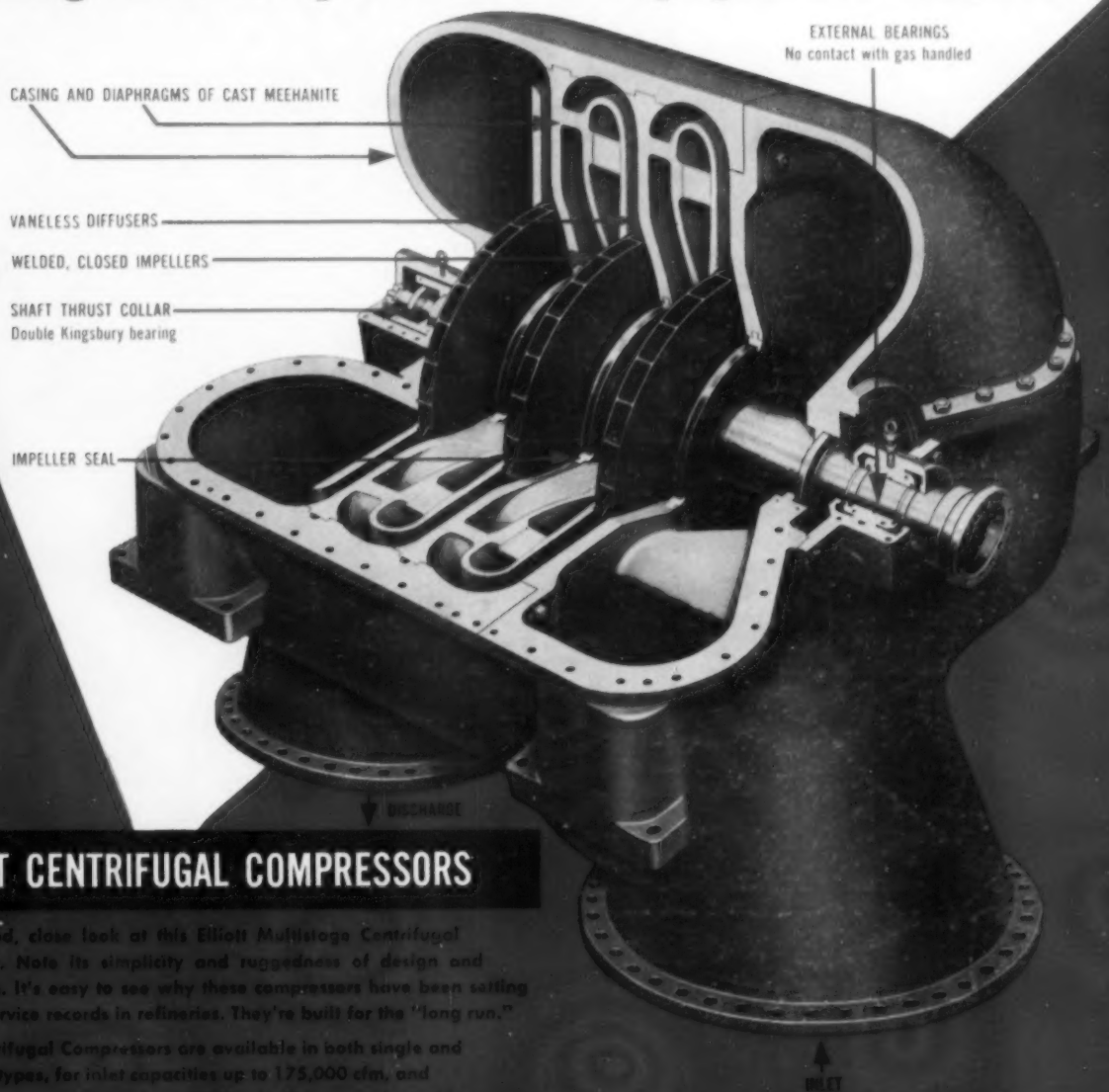
18th ANNUAL PROCESS ISSUE

- *New Processes*
- *First Units*

PLUS

"How to Get Those Top Octanes"

Pointing the way to non-stop performance



ELLIOTT CENTRIFUGAL COMPRESSORS

Take a good, close look at this Elliott Multistage Centrifugal Compressor. Note its simplicity and ruggedness of design and construction. It's easy to see why these compressors have been setting non-stop service records in refineries. They're built for the "long run."

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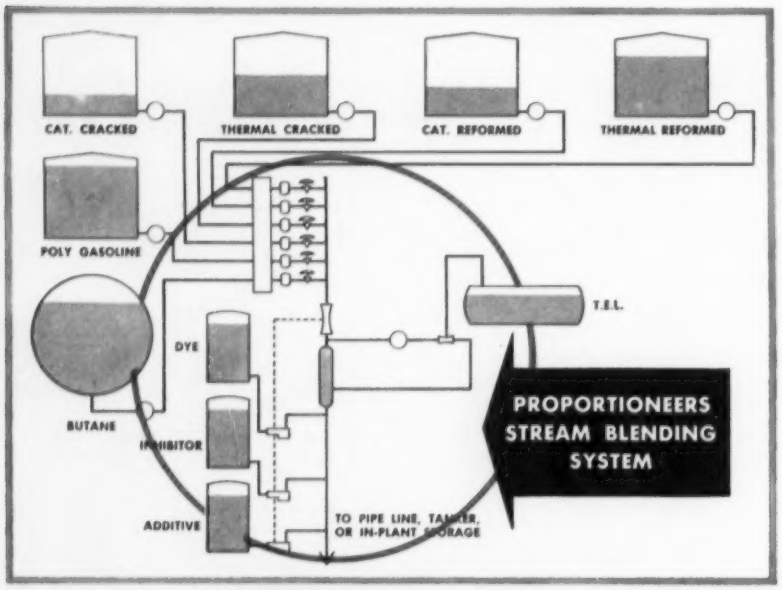
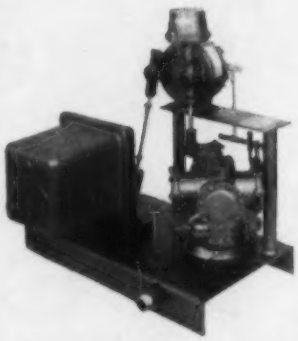
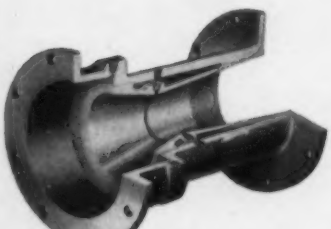


Chlorine gas feeders.



Flow responsive additive blenders.



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B-I-F METERS FEEDERS CONTROLS

Volume 34, No. 9 September, 1955

PETROLEUM
REFINER
REFINING | PETROCHEMICALS | NATURAL GASOLINE

18TH ANNUAL PROCESS ISSUE

Process Issue '55 121
George B. Gibbs
Process Boxscore 122
New HF Alkylation Process 126
W. D. Peters and C. L. Rogers
Applying RDC to Lube Extraction 129
G. H. Reman and J. G. van de Vusse
Iso-Plus Offers Three Routes 135
Henry D. Noll
What to Do With Acid Sludge 138
G. Hunter Miley
First Dualayer Treater for Fuel Oil 142
C. A. Duval, R. T. Malin and V. A. Kalichevsky
Rexforming Looks to First Unit 145
William K. Hunter
Alkylating with Effluent Refrigeration 148
A. R. Goldsby and D. H. Putney
Shell "Trickle" Hydrodesulfurizer 152
H. G. Klinkert and H. M. Penning
New Process for Mercaptan Removal 155
Ralph Miller and Joseph H. Salmon
Diesulforming Operates This Way 158
F. B. Odass and J. V. Sheffield
Orthoforming Unit Produced 100 Clear 164
Robert G. Christopher
How Houdresid Works on Heavy Stocks 166
Rophie E. Bland
Catforming at United Refining Company 169
H. A. Logan, Jr., B. E. Milner and J. A. Nevison
Ultraformer Tops 100 Octane 174
T. M. Moore
Bender Process Sweetens at No Loss 182
L. C. Waterman and R. A. Wiley
First Kellogg-Designed Cat Reformer 190
George W. Stanford
Cut Costs in Distillate Treating 194
R. J. Phillips
How the First TCP Unit Operates 206
A. O. Pukkila and G. L. Payne
How to Start Up a Fluid Cat Cracker 214
Walter Ulrich
High-Sulfur Crudes Need New Processes 220
W. H. Winslow
How to Get Those Top Octanes 230
Marshall Sittig and Wayne Warren
Taking Stock 282
Cecil W. Smith

As Management Sees It

How to Stretch Your Power Dollar 116
Luther W. Davis
Microfilmed Data Offer Easy Way Out 118
Carl Cline
Developing Technical Personnel 328
Rex E. Gilbreath
Safety Needs Promotion 338
J. E. Bedford
How to Build Presenteeism 348
Auren Uris

DEPARTMENTS

Quick Look 4
Mail Box 101
Quick Look at Industry 107
Look Box 111
Valuable Reading Ahead 284
How to Do It 287
Who's Building 298
What's Happening 364
Men in Industry 376
Heard at Meetings 390
Meetings Calendar 392
Reviewing New Books 394
Suppliers' Notes 400
Classified Advertising 423
New Equipment 427
New Literature 440
Index to Advertisers 441
Readers' Service Card 443

A Quick Look at This Issue

These handy digests permit checking those articles you want to read first.

☐ **New HF Alkylation Process** . . . This process comes at a time when many refiners are considering alkylate for motor fuel blending. The extreme simplicity of the process, compared to the early wartime aviation alkylate units, is readily obvious in this discussion of process flow and operating costs. Payouts for units of 1000 to 4000 barrels alkylate per day capacity usually average between one and 1½ years. **Page 126.**

☐ **Applying RDC to Lube Extraction** . . . Here's the first operating data on this new countercurrent extraction tool—the rotating disc contactor—as used in the extraction of lubricating oil fractions with furfural. At present five are in operation and each shows a high separating power which gives rise to large yields of high-quality raffinate. **Page 129.**

☐ **Iso Plus Offers Three Routes to Higher Octane Gasoline** . . . All these routes are based on the use of the Houdriforming process. Two involve the addition of aromatics extraction equipment and the third adds thermal reforming. Any of the routes will boost reformate above 100 clear octane. **Page 135.**

☐ **What to Do With Acid Sludge** . . . A new process from Sonneborn's Daugherty refinery will produce 65 percent pure SO_2 from acid sludge. A specially designed retort decomposes the sulfuric acid sludge in a continuous stream. A 50-ton unit costs about $50,000, exclusive of license fee. **Page 138.**

☐ **First Dualayer Treater for Fuel Oil** . . . First published data on Magnolia's Dualayer process installation for distillate fuel oil treatment shows excellent stability in treated products. Good color and low sediment content characterize the treated distillates. The installation itself was inexpensive and consumption of chemicals has been small since the unit began operating last year. **Page 142.**

→ Now Turn the Page →|

A Quick Look at This Issue

☐ **Rexforming Looks to First Unit** . . . Three Rexforming units are being designed now; Aurora Gasoline Company's unit at Detroit will probably be the first completed. In this article you'll find how the process works, what pilot plant studies show, and how much it will cost. **Page 145.**

☐ **Alkylating with Effluent Refrigeration** . . . The first sulfuric acid unit with effluent refrigeration produces 95 (F-1) clear alkylate at an acid consumption of less than 0.3 pound per gallon of alkylate. This unit at The Texas Company's Amarillo refinery is of unusual commercial interest because many refiners are turning to the alkylation process for motor fuel production. Other features of this process: Lower capital investment, increased yield and decreased operating cost. **Page 148.**

☐ **Shell "Trickle" Hydrodesulfurizer** . . . First unit for this process is at Stanlow, England. Operating data shows that this installation has exceeded expectations from pilot plant studies—over 90 percent of the sulfur has been hydrogenated in runs on light cycle oils. The main feature of the process is the application of low hydrogen recycle flow rates. **Page 152.**

☐ **New Process for Mercaptan Removal** . . . Employing sodium ferrocyanide as an additive to caustic soda, this process uses electrolysis to regenerate caustic completely. Capital and operating costs are low. In some instances a doctor sweet product is obtained solely by extraction. **Page 155.**

☐ **Diesulforming Operates This Way** . . . The operating data in this article is from the first diesel desulfurization unit on stream in the United States. Although any sulfur-bearing stock may be charged to the unit, distillates in the diesel fuel boiling range are the most popular charge. Husky Oil Company plans another unit like the first one for its Canadian refinery. **Page 158.**

☐ **Orthoforming Unit Produced 100 Clear** . . . This catalytic reforming unit at Whiting has produced 100 octane (clear) reformate during its first months of operation. Similar to Orthoflow catalytic cracking, the unit has an integrated reactor, regenerator and stripper. No pretreatment of the feedstock is required. It operates at low pressure—200-250 psig. **Page 164.**

☐ **How Houdresid Works on Heavy Stocks** . . . One year's commercial operation and pilot plant studies indicate that this cat cracking process experiences no trouble with heavy metal contamination. The process is well adapted to the use of synthetic or natural clay catalyst and to the charging of a wide range of reduced crudes. Heavy gas oil is recycled completely. **Page 166.**

☐ **Catforming at United Refining Company** . . . Authors take you stepwise from testing the new catalytic reformer to start-up, shut down, and regeneration. Complete operating results include inspections of charge and products, a yield-octane plot, and temperatures with reformate octanes. **Page 169.**

☐ **Ultraformer Tops 100 Octane** . . . The Texas City unit—one of six Ultraformers now operating—produced over 100 clear octane reformate. This story on the first six units includes inspections of charges and yields. **Page 174.**

☐ **Bender Process Sweetens at No Loss** . . . This process sweetens hydrocarbons in the gasoline-middle distillate range at no loss in the system. Chemical costs run around ½c per barrel and the catalyst can be regenerated at the plant site. **Page 182.**

☐ **First Kellogg-Designed Cat Reformer** . . . Using the Sinclair-Baker catalyst, Pure's Heath refinery found no need to regenerate the platinum catalyst after nine months of operation. Typical operating data from this unit show operation at both the 90 and 85 octane (clear) level. A feed preparation section is provided to insure long catalyst life and maximum yield of reformate. **Page 190.**

☐ **Cut Costs in Distillate Treating** . . . Electrical precipitation permits lower chemical consumption and reduces carry-over of addition agent in treated product. A return of 416 percent per year is claimed for the $50,000 investment in this process. Non-recurring credits are also listed in full with other economic credits. **Page 194.**

☐ **How the First TCP Unit Operates** . . . The Thermofor Continuous Percolation unit at Coryton (for finishing lubricating oils) chalks up oil losses of less than one percent. Clay losses are only about one percent per cycle of circulation. Yields exceed those with laboratory static percolation by 35 to 45 percent. **Page 206.**

☐ **How to Start Up a Fluid Cat Cracker** . . . Every process man should know at least these fundamentals about starting up a unit of this type. Besides the stepwise procedure, author also offers helpful hints on what to watch for during the start-up and operation of the unit. **Page 214.**

☐ **High Sulfur Crudes Need New Processes** . . . Trends in crude production indicate heavier, higher sulfur charge stocks for refineries. Here's an example calculation on the addition of such crudes to a low-sulfur refinery. Fluid coking and Hydrofining are shown to join hands in making the processing economical. **Page 220.**

☐ **How to Get Those Top Octanes** . . . You'll want to check every division of this comprehensive 51-page monograph on octane improvement techniques: All about reforming; Consider Also Isomerization; Dollars and Cents of Octane Improvement; Can You Save with TEL?; What Reforming Processes Give You; Poly and Alkylate Play a Part; Don't Forget Process Combinations; PLUS 329 references. It includes the most authoritative comparison of catalytic reforming to date. **Page 230.**

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18

OUR NUMBER is up and it's 18 this year. This issue represents our 18th edition of the special Process Issue. When the first issue came out in 1932, copies went so fast that to get his copy one refiner had to buy an ad in REFINER offering $5 to anyone who could furnish him a copy. And that was 1932 when $5 plus the cost of the ad was a lot of money. Even at present inflation rates though, you'll find this 18th edition equally valuable. It's the most exciting tour through refinery processing today. Don't stop until you've seen the 51-page report on "How to Get Those Top Octanes." It includes the most authoritative comparison of catalytic reforming to date.

Don't Trip on the Skip

THERE WAS started in the August issue, as the lead of our "Exchanger Design Aids," a series authored by Daniel A. Donohue which deserves more than passing notice. Entitled "Heat Exchanger Design," the four installments will give the reader just about all he needs to know on the construction features of various types of exchangers, tube layout and flow areas and flow paths. Part II, Fundamentals, due to the usual scheduling of the Process Issue each September, has to be held over until October. Don't overlook this working notebook material.

Author Donohue, Chemical Construction Company engineer, has been hard at design in the industry since 1937. He is a chemical engineering grad from Brooklyn Polytechnic, holds a master's degree in chemistry from Columbia and has taken another year of graduate courses in chemical engineering there. Since 1951 he has taught graduate courses in heat transfer at Brooklyn Polytechnic.

Nomograph— Do It Yourself!

MAKE YOUR own nomographs? Haven't you envied the few friends of yours who can take some experimental data, or a complicated formula, and end up with a simple nomograph for rapid calculations? We have too . . . so we made arrangements with Francis Winn for a series on this helpful subject. He will take you by the hand through each step and show you that making a nomograph is really a simple thing. You will agree that this is the easiest presentation of nomography that you've ever seen. Four parts, starting in the October issue. You'll like it.

Enroute

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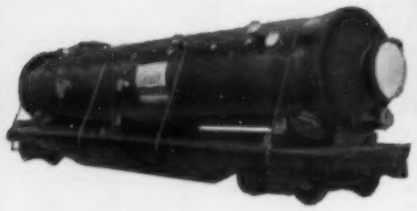

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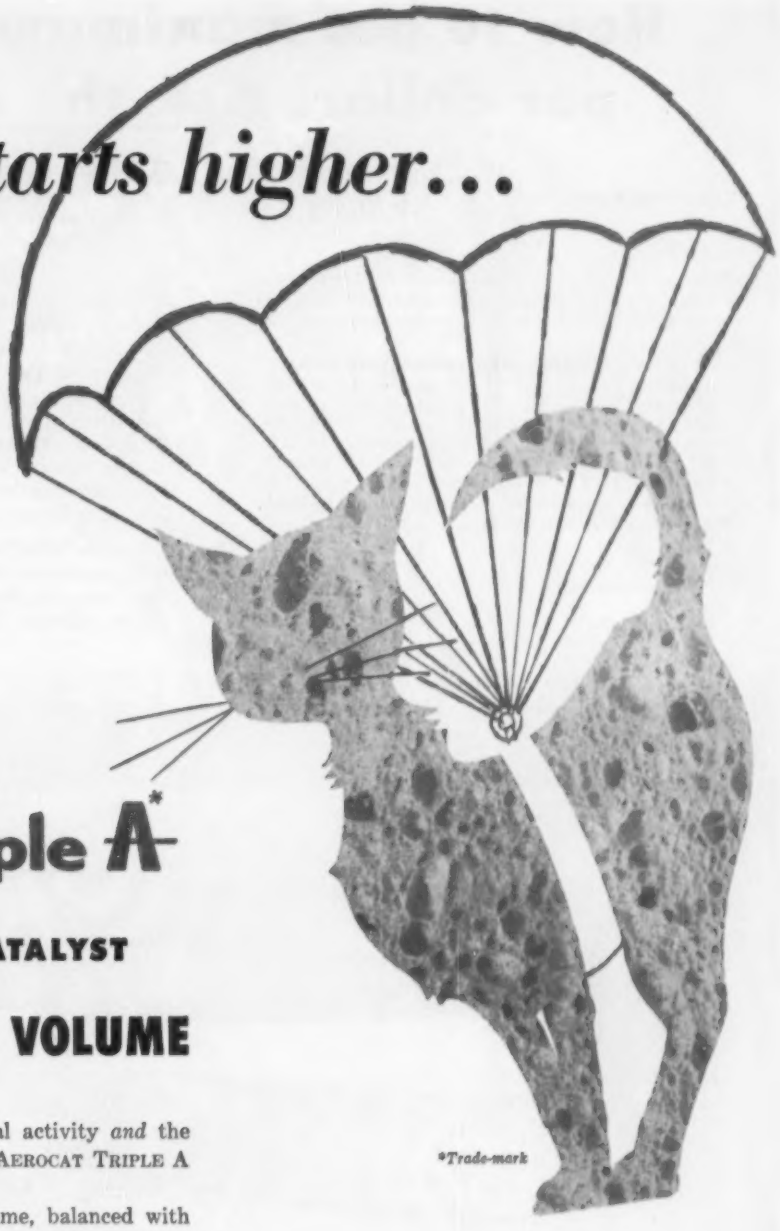

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How to get maximum tube life per dollar: Ask the experts!

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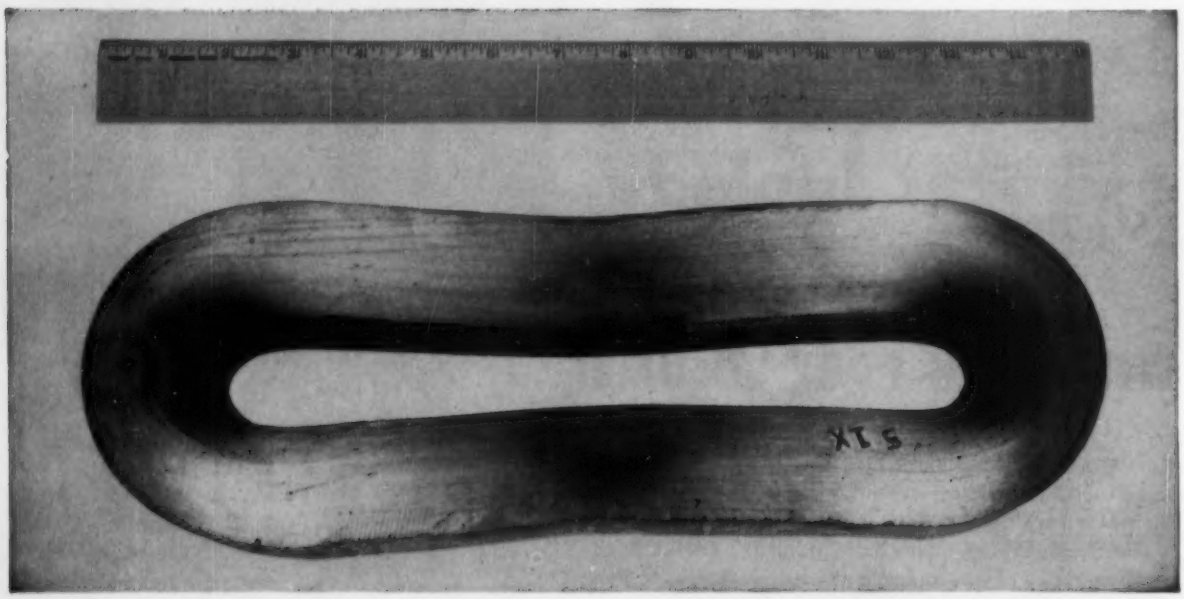

Flattened test of 10½" O.D. by 1.580" wall of 18-8 Cb showing the excellent ductility of large, heavy-wall Timken seamless tubing.

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Although recommendations for your specific needs can be made only after thorough analysis, you can get more information about use of this series by obtaining a copy of Allis-Chalmers Water Conditioning Informational Bulletin 50. Get a copy from your nearby A-C office or write Allis-Chalmers, Milwaukee 1, Wisconsin.

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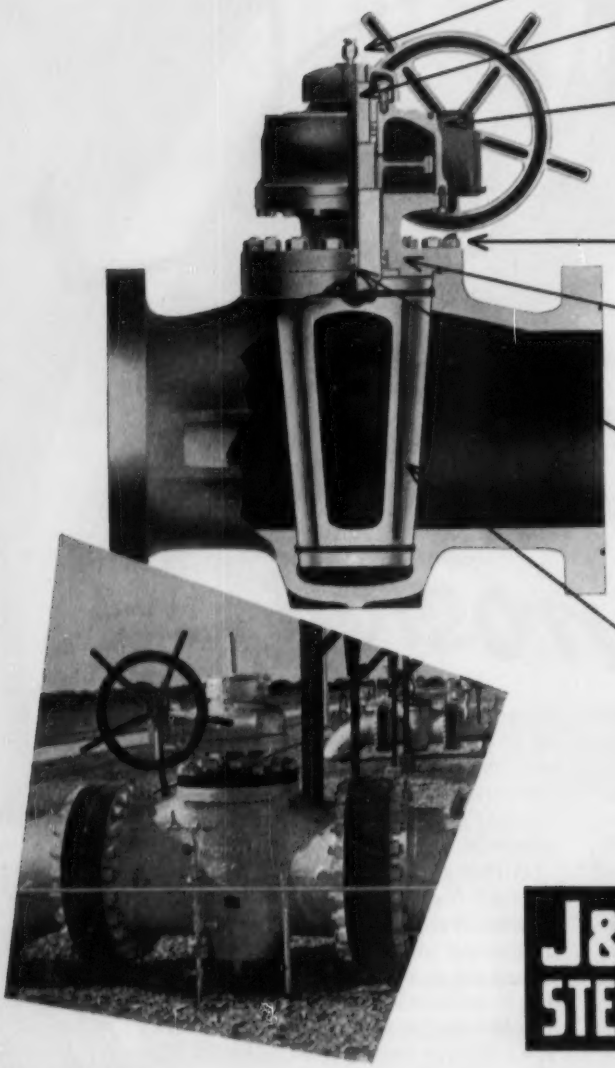
LET'S EXAMINE WALWORTH LUBRICATED PLUG VALVES



Button-head lubricant fitting and lubricant screw. Screw is not removed when using a Walworth High Pressure Lubricant Gun.

Lubricant-Fitting screw has "Telltale" safety groove.

For buried pipelines this yoke design permits simple attachment of handwheel and lubrication extensions without modifying the gearcase.

Standard bolt threads, rather than special threads, permit easy replacement from local stocks.

Two overlapping Teflon packing rings form an effective seal against leakage without "grabbing" the plug shank. Packing serves only as a seal and is not used to hold the plug in its seat.

In the stainless steel check valve unit, a transverse pin holds two balls in their seats. There is no chance for line pressure to get into the lubricant system when the valve is properly adjusted and lubricated.

Lubricant grooves completely frame the port openings and encircle the plug at the top and bottom, assuring a tight seal against leaks. Bottom circumferential groove is separate from, but connected with, the lubricant well.

ADVANTAGES OF PLUG VALVES

1. Quick Opening.
2. Positive seal on Light Hydrocarbons.
3. Less space than Gate Valves.
4. Available in Three-Way and Four-Way.
5. Can be used with Locking Device.

J&L STEEL

Jones & Laughlin
STEEL CORPORATION
SUPPLY DIVISION – Tulsa
SERVING THE UNITED STATES AND CANADA

125-G

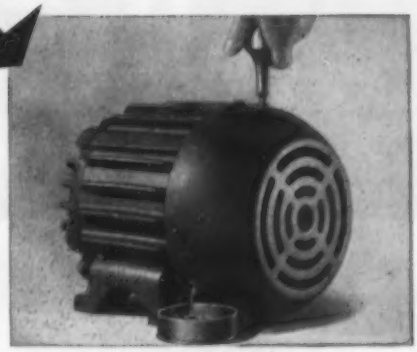
Get Both
bearing features

The bearing is enclosed with a bearing cap held tightly in place against the inner face of the bearing enclosure. This cap, with its close running clearances, keeps grease from the interior of the motor . . . retains an ample supply within the bearing enclosure.

At the outer side of the bearing, double labyrinth seals keep grease in, also keep dirt out. What's more, large grease reservoirs act as additional dirt traps.

fully enclosed and protected
. . . yet
easy to grease

You can lubricate the bearings without dismantling the motor. Pipe-tapped holes in the bearing housings at three points provide both means for inserting new grease and a means of flushing out old grease.

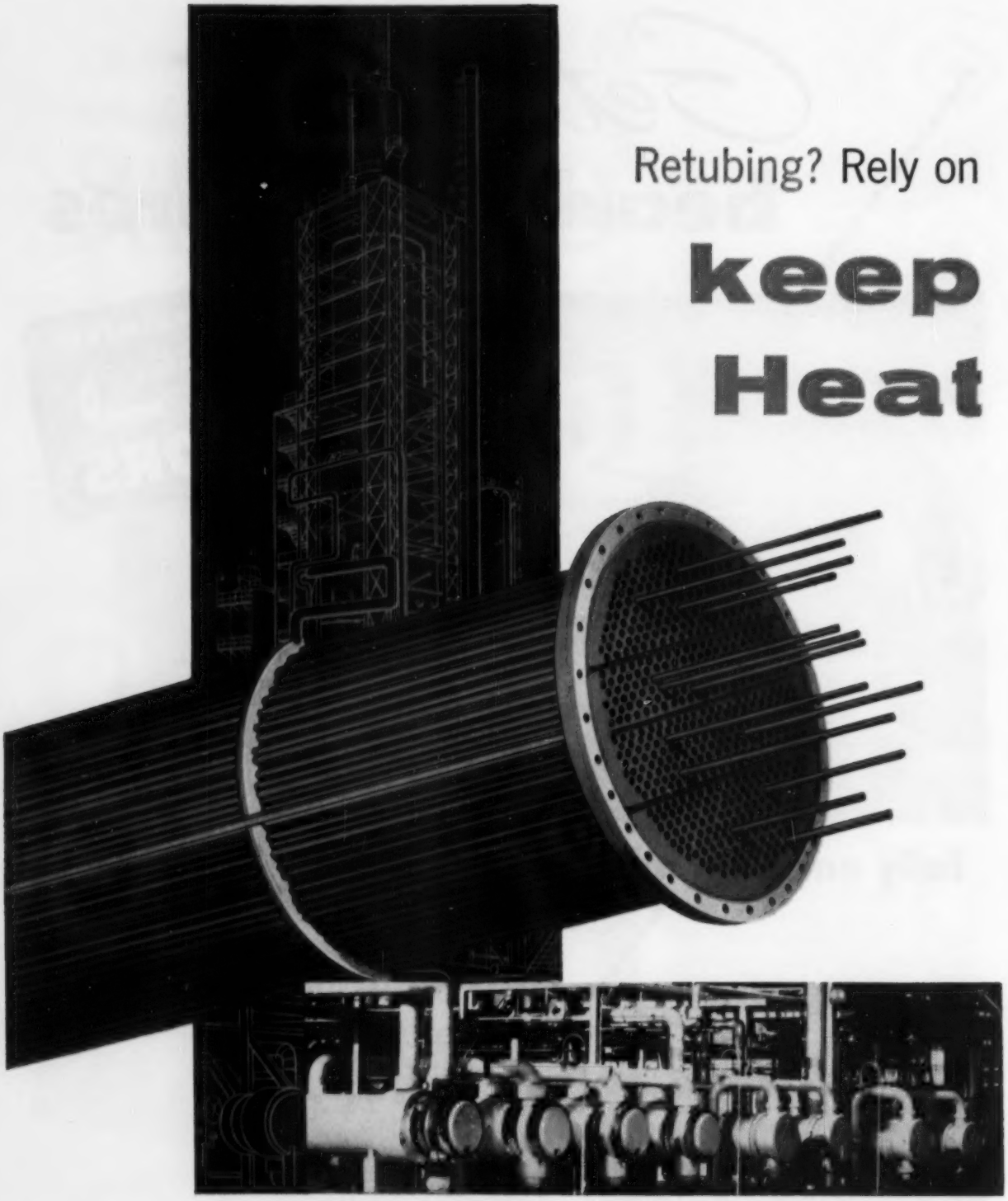


Look for the extra bolts on the end housing . . . the sign of greater value. Ask your Allis-Chalmers representative or Authorized Distributor to show you a cutaway section of this maintenance-cutting design. Or write Allis-Chalmers, Milwaukee 1, Wisconsin, for Bulletin 51B7286.

A-4610

ALLIS-CHALMERS

For more data on advertised products, use Readers' Service Cards, last page.



Retubing? Rely on

keep Heat

First for Lasting Quality—from Mine to Market!

Phelps Dodge COPPER-BASE ALLOY Tubes to

your Exchangers On-Stream!

- **Complete line of copper-base alloys** including Bi-Metal combinations to meet special corrosive conditions.
- **Speedy delivery** from strategically-located warehouses.
- **Careful analysis of your corrosion problems** by experienced engineering staff.
- **Quality-controlled fabrication** to assure finest tube properties.
- **Information and sales service** available from nearest Phelps Dodge district office.*

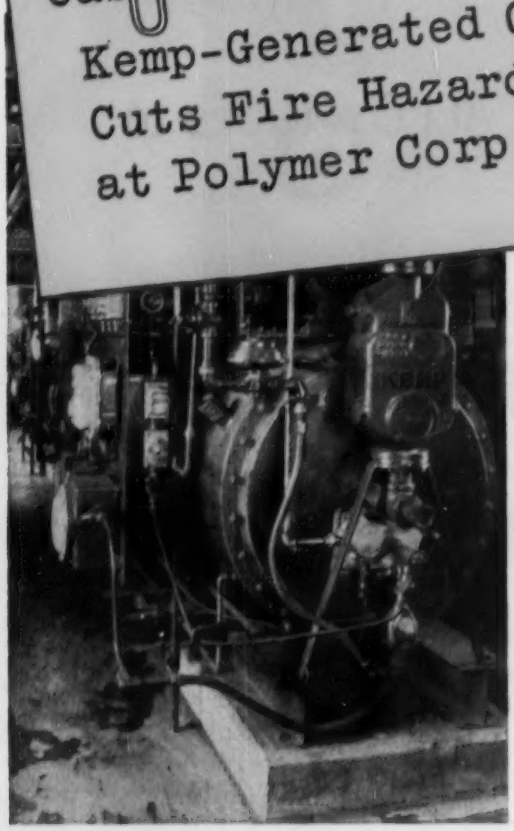
PHELPS DODGE COPPER PRODUCTS CORPORATION

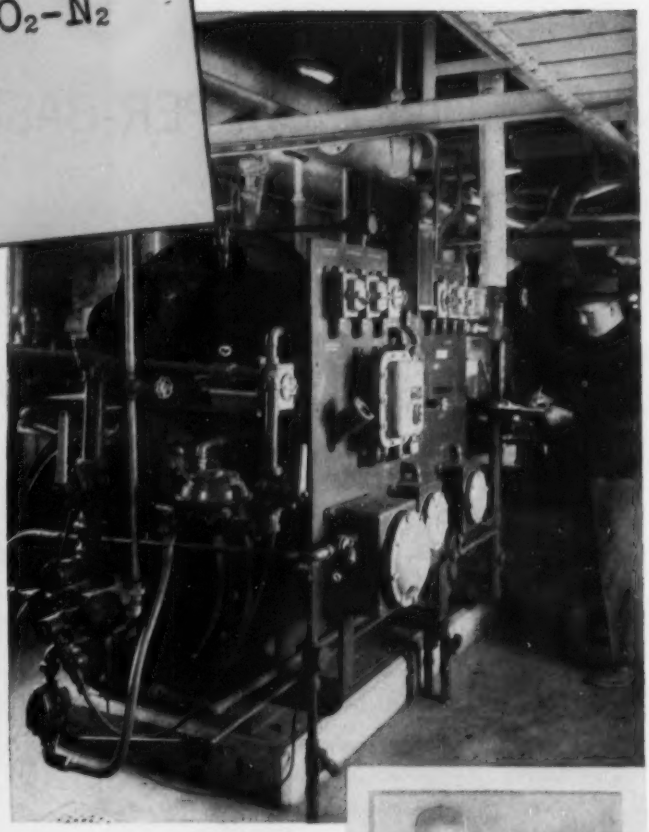
*SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle Washington, D. C.

For more data on advertised products, use Readers' Service Cards, last page.

Case No. 62

Kemp-Generated CO_2-N_2 Cuts Fire Hazard at Polymer Corp.





How Polymer operated day and night for 10 years at maximum safety

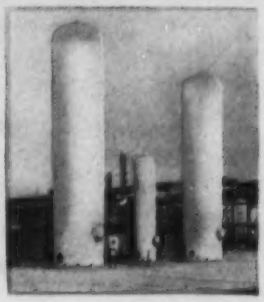
When Polymer Corporation, Ltd., Sarnia, Ontario, began operations in 1943, inventory included two Kemp MIHE Inert Gas Generators. Since that date, Polymer—and its Kemp equipment—has been operating 24 hours a day, 365 days a year. The huge quantities of man-made rubber and associated chemicals it produces—200,000,000 pounds during one year alone—reach, in one form or another, the four corners of the world.

Kemp Plays an Important Role

The high volatility of many of the ingredients used in this giant operation necessitates blanketing and purging vessels after use. It is in this step that Polymer employs Kemp Generators to assure safe, trouble-free performance. The gas they produce is piped to different operations over the entire company area—it *must* be clean! Kemp does the job—Polymer knows that it can depend on Kemp to deliver a *clean inert at a specific analysis, regardless of demand*. And every Kemp Generator is engineered for fast starts and easy operations that save *time* and *money*.

Kemp Can Do a Job for You

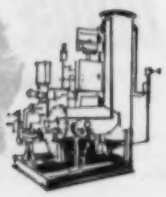
Kemp superiority is no accident. It is based on years of experience . . . on quality of design to meet specific problems. Every Kemp design features the Kemp Industrial Carburetor for complete combustion without tinkering or waste . . . for simplified installation and maintenance. Every Kemp design includes the latest fire checks and safety devices. If you have a blanketing or purging problem, contact Kemp engineers. They will be glad to study your situation and recommend the installation best suited to your needs. No obligation, of course.



Gas generator building from which inert gas is piped over 130 acres of company property at Polymer's Sarnia, Ontario, operation.

For more complete facts and technical information, write for Bulletin I-10 to: THE C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.

KEMP OF BALTIMORE



INERT GAS GENERATORS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • ADSORPTIVE DRYERS
SINGEING EQUIPMENT

Toward
Tomorrow's
new world

PROCESSES & PLANTS
BY CATALYTIC

YOUR ENGINEERING PROBLEMS OF TODAY in chemicals, petrochemicals, metallurgy, atomic energy and petroleum...are met with CATALYTIC'S broad and diversified experience, imagination and skill—to give you better and more profitable products for tomorrow's new world.

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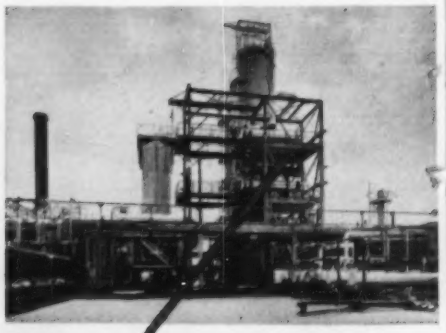
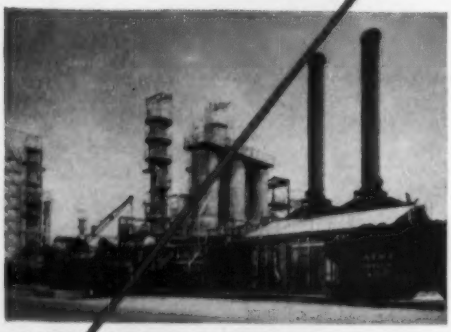
Catalytic Construction of Canada, Limited
Sarnia, Ontario

CATALYTIC *ON-TIME...ON-BUDGET* SERVICES for the metallurgical, chemical, petrochemical and oil refining industries
Project Analysis Process Development Process Design Economic Studies Engineering Procurement Construction Plant Operation

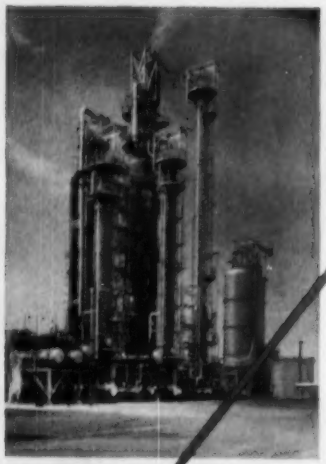
Another Complete Refinery



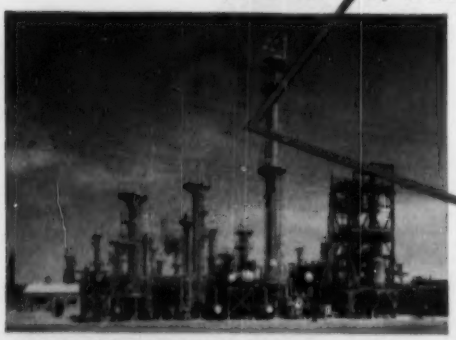
CRUDE UNIT: capacity 10,000 barrels per calendar day.



DELAYED COKING UNIT: 2,500 barrels a day reduced crude; produces approximately 74 tons a day of coke.

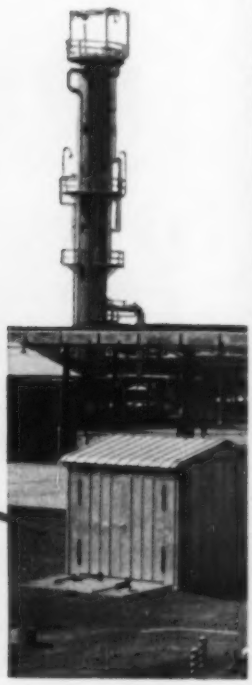


CATALYTIC CRACKING UNIT: capacity 7,000 barrels a day of total feed.



CATALYTIC POLYMERIZATION UNIT: capacity 1,700 barrels a day of mixed $C_3 - C_4$ stream.

CATALYTIC REFORMING: 3,500 barrels a day of heavy naphtha.



FOSTER

NEW YORK • LONDON

Built for The Texas Company at El Paso, Texas, this new integrated refinery consists of crude and delayed coking units, as well as units for catalytic cracking, polymerization and reforming.

To companies the world over that now are contemplating new refinery expansion, Foster Wheeler offers the significant advantages of its worldwide experience in the design, engineering and construction of completely integrated refining facilities. For proposals to meet your specific requirements, write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

WHEELER

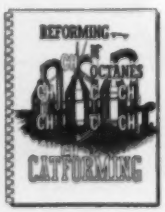
PARIS • ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.

CATFORMING *means*

High Octanes...
High Yields...
Low Cost...
Proved Performance

These advantages of Atlantic Catforming are being demonstrated again and again in different commercial installations. We invite you to share in the benefits of Catforming. Please phone, write or wire for our detailed brochure, "CATFORMING." The Atlantic Refining Company, Research and Development Dept., P. O. Box 8138, Philadelphia, Pa.



ATLANTIC *It's the Catalyst that counts*

CERAMIC BALLS for thermal pyrolysis and catalyst support beds

As a heat transfer and catalyst support medium in various refinery operations, "U.S." Ceramic Balls are proving unusually effective. They are being widely used in the field of pyrolysis and in catalytic reforming installations.

"U.S." Ceramic Balls possess heat-shock resistance, great crushing strength, superior thermal conductivity and high specific heat. The material is thoroughly vitrified, inert and is particularly recommended for its proven resistance to erosion and abrasion.

The smooth surface and spherical shape of "U.S." Ceramic Balls have proven more efficient than irregularly sized and shaped heat transfer elements. A special body ("CERATHERM-550") is available where exceptional thermal-shock and heat-resistance characteristics are required.

All sizes are available from 1/4" O.D. to 3" O.D.

1278

CHEMICAL CERAMICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

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New York

20 North Walker Dr.
Chicago

4101 San Jacinto St.
Houston

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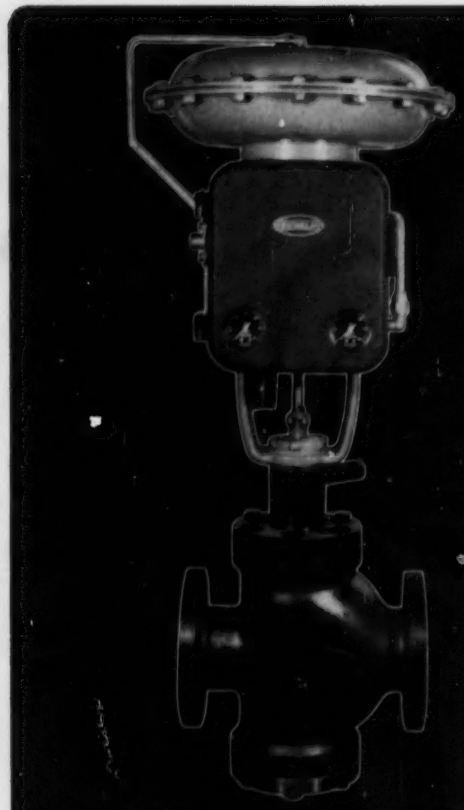
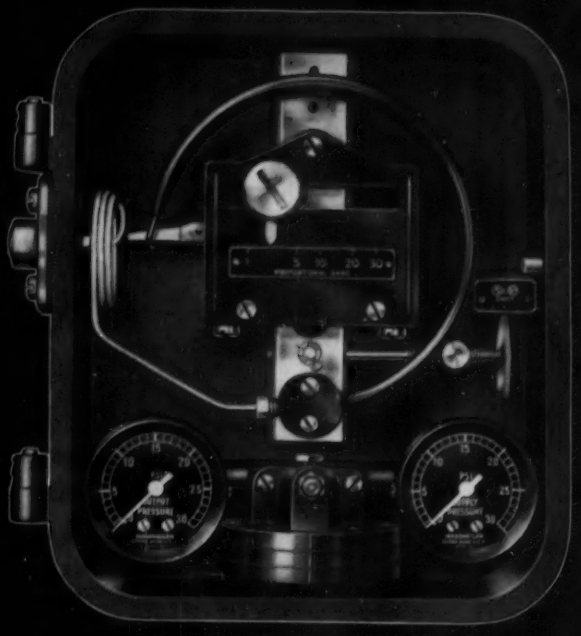


Model 2807 — Valve Mounted.



Model 2800 or 2807 with Bourdon Element Positioned for Direct Action. Proportional Band 1% to 30%. Valve, Surface or Panel Mounting.

FAST RESPONSE

with High-Capacity Relay Pilot

HIGH SENSITIVITY

Virtually No Lost Motion

LOW COST

Moderate Price — Low Operating Cost

Model 2830 or 2837 Differential Gap Controller Positioned for Direct Action. Gap Width 1 to 50%. Valve, Surface or Panel Mounting.

MASONEILAN

Model 2800 — For Panel Mounting.

Select Masoneilan 2800 Series for Better Low Cost Pressure Controllers

These new controllers combine all the basic requirements of pneumatic proportional controllers with the added features of a high capacity, balanced, amplifying relay pilot; proportional band setting as narrow as 1% (as wide as 30%); pneumatic feedback; reversible action. Simplicity is achieved by unit construction of subassemblies and air passages integral with the case. Models 2807 and 2837 are provided with rugged weatherproof cases for outdoor use — suitable for valve or surface mounting.

A wide selection of pressure ranges is available between 30" Hg Vac and 10000 psi, with bourdon or bellows primary elements of materials most suitable for the pressure and fluid conditions.

The performance of these controllers, obtainable at moderate cost, makes the advantages of instrument control feasible for the majority of pressure control applications.

A companion model (3800 Series) is available for temperature service — with same high quality features. Employs vapor pressure thermal system; suitable ranges up to 550°F.

Investigate these controllers — ask our representative nearest you, or write for details.

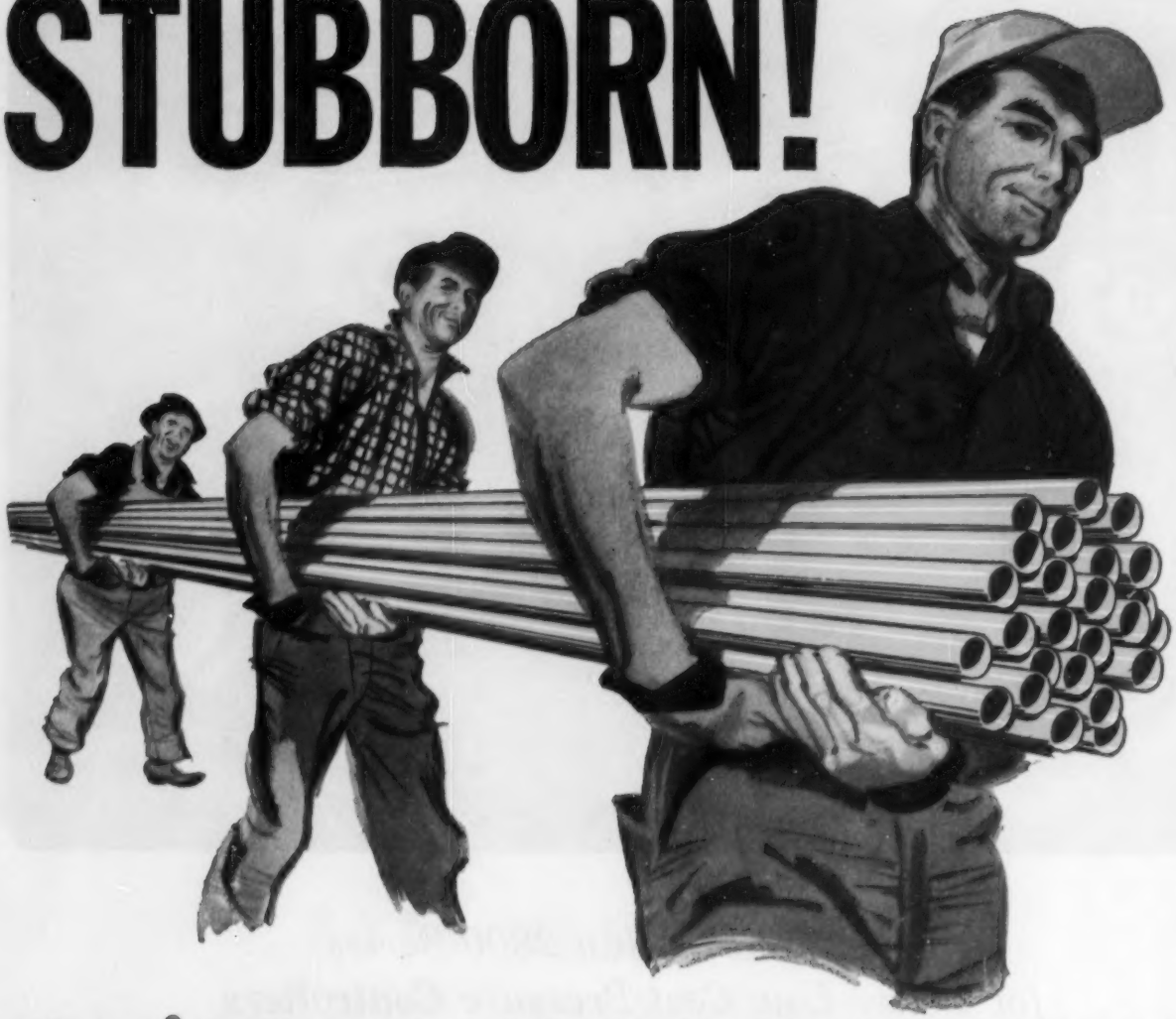
MASON-NEILAN REGULATOR CO.

1182 ADAMS STREET, BOSTON 24, MASS., U. S. A.

Sales Offices or Distributors in the Following Cities: **New York • Syracuse • Chicago • St. Louis • Tulsa Philadelphia • Houston • Pittsburgh • Atlanta • Cleveland • Cincinnati • Detroit • San Francisco Boise • Louisville • Salt Lake City • El Paso • Albuquerque • Odessa • Charlotte • Los Angeles Corpus Christi • Denver • Appleton • Birmingham • New Orleans • Dallas • Seattle Mason-Neilan Regulator Co., Ltd., Montreal and Toronto**

For more data on advertised products, use Readers' Service Cards, last page.

STUBBORN!



Chase® Antimonial Admiralty Heat Exchanger Tubes *RESIST DEZINCIFICATION!*

Dezincification holds no fears for the users of Chase Antimonial Admiralty Heat Exchanger Tubes! For *this* special alloy can give *years* of extra service under the most corrosive conditions!

Rugged testing in Chase laboratories, plus careful manufacturing in Chase mills, team up to give Chase Antimonial Admiralty a longer, healthier life span. To you, this can mean lower operating costs, fewer breakdowns, longer waits between tube replacements.

Enjoy these benefits! Insist on Chase Antimonial Admiralty!

CHASE WAREHOUSE STOCKS: Houston,* Los Angeles, New Orleans, Tulsa**

*Handled by Standard Brass & Mfg. Co. **Handled by Vinson Supply Co.

Chase®

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

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Baltimore	Cleveland	Houston	Milwaukee	Philadelphia	San Francisco
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Grace Chemical Company Selects an Air Products INCORPORATED AIR SEPARATION PLANT

GRACE CHEMICAL COMPANY
3 HANOVER SQUARE, NEW YORK 4, N.Y.

W. P. GAGE
PRESIDENT

March 1, 1955

Mr. C. R. Anderson, Vice President
Air Products, Incorporated
P. O. Box 538
Allentown, Pennsylvania

Dear Mr. Anderson:

The Grace Chemical Company's new anhydrous ammonia-urea plant at Memphis, Tennessee has been "on-stream" now for some time. The successful operation of the equipment is in no small part due to the manner in which the air separation unit has functioned.

The low-temperature equipment supplied by your company was erected under the supervision of your engineering staff with a very minimum of difficulty. The presence of your men during the plant "shake-down" period contributed greatly to our starting production with less delay than normally is to be expected on a project of this size.

Very truly yours,
GRACE CHEMICAL COMPANY
W. P. Gage

WPGaew

Air Products Air Separator in Grace Chemical Company's new ammonia plant.

Grace Chemical Company, subsidiary of W. R. Grace and Company, has started operations at its new anhydrous ammonia-urea plant at Memphis, Tennessee. The new plant was constructed to put this century-old firm into the relatively new agricultural chemical field on a large scale. Production is expected to exceed the rated capacity of 90,000 tons of ammonia and 54,000 tons of urea annually.

An important unit in the process is the air separation plant designed and built by Air Products, Inc. to split air into nitrogen and oxygen. Air Products has built over 700 air separators which are being operated successfully throughout the world.

Satisfaction, from the initial inquiry to the successful operation of the plant, is assured when your low-temperature processing work is entrusted to Air Products.

If your project calls for gas separation by low-temperature processing, get in touch with us.

36-page brochure discusses the broad possibilities of low-temperature processing and describes Air Products' facilities. Write for a free copy.

Air Products INCORPORATED

Dept. X, Box 538, Allentown, Pa.

Specialists in Low-Temperature Processing

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POWELL VALVES ... THE COMPLETE QUALITY LINE ... POWELL VALVES

POWELL VALVES FOR PETROLEUM PROCESSING

Fig. 1793 — Flanged End Iron Body Bronze Mounted O.S.& Y. Gate Valve for 125 pounds. 2" to 30", inclusive.

Wherever fluids are handled in Petroleum Processing and the making of Petrochemicals, use Powell Valves—and *be sure*. Powell not only offers all kinds of valves—in bronze, iron, steel and a wide selection of corrosion-resisting metals and alloys—for every flow control requirement of the Petroleum Refining Industry, but they have been doing it for years—since 1846. Is it any wonder that leading refiners depend on Powell Valves? Ask your distributor. If none is near you, write—

THE WM. POWELL CO., CINCINNATI 22, OHIO.

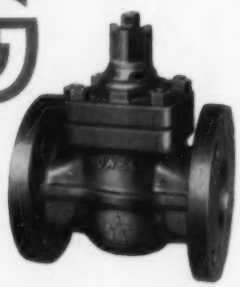

Fig. 2201—Flanged End Semi-Steel Lubricated Plug Valve. 1" to 4", inclusive. Plug Valves also available in Bronze, Carbon Steel, Stainless Steel, Ni-resist and Monel Metal. Sizes up to 12".

Fig. 3003—Flanged End Steel Gate Valve for 300 pounds. 1" to 30", inclusive. Available for 150 pounds and through 2500 pounds.

Fig. 2491—Flanged End Stainless Steel O.S.& Y. Gate Valve for 150 pounds. ¼" to 2". 300 and 600 pound valves available.

Fig. 1561—Flanged End Steel Swing Check Valve for 150 pounds. ½" to 18", inclusive. Available through 2500 pounds.

Fig. 375 — Screwed End Bronze Union Bonnet Gate Valve for 200 pounds. ¼" to 3", inclusive.

POWELL VALVES ... THE COMPLETE QUALITY LINE ... POWELL VALVES

IN SURFACE COATINGS *(Paint, Varnish, Shellac)*

IN PETROLEUM *(Gasoline Additives, Lubricants)*

IN CHEMICALS *(Synthetic Fabrics and Yarns)*

Enjay assures you satisfied customers

To satisfy your customers with high quality, dependable products, specify Enjay chemicals. The Enjay Company supplies a diversified line of uniform, high quality petroleum chemicals to the surface coating, chemical and petroleum industries. Through the facilities of the *new Enjay Laboratories* you can be assured of the best application of Enjay products in your chemical needs.

PETROLEUM
PARANOX
PARATONE
PARAFLOW
PARAPOID
PARADYNE
PARATAC
PETROHOL
Methyl Ethyl Ketone
Dewaxing Aid
Ethyl Ether
Isopropyl Ether
Reference Fuels

RUBBER
ENJAY BUTYL
VISTANEX

SURFACE COATING
PETROHOL 91
PETROHOL 95
PETROHOL 99
JAYSOL
Secondary Butyl Alcohol
Secondary Butyl Acetate
Isopropyl Acetate
Acetone
Methyl Ethyl Ketone
Dicyclopentadiene
Ethyl Ether
Isopropyl Ether
Naphthenic Acids
Iso-Octyl Alcohol
Decyl Alcohol
Denatured Ethyl Alcohol

CHEMICAL
PETROHOL 91
PETROHOL 95
PETROHOL 99
JAYSOL
Iso-Octyl Alcohol
Decyl Alcohol
Denatured Ethyl Alcohol
Tridecyl Alcohol
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ENJAY

35 successful years of leadership in serving industry

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OLDEST

...yet

KIELEY & MUELLER is the *oldest* control valve manufacturer in the United States.

However, K&M offers the *newest* diaphragm control valve design. The K&M Series 1400 diaphragm control valve was not *adapted* to high lift, it was *completely designed* for it. That's why K&M exceeds today by every measure of control valve performance . . . and valve manufacturing experience. That's why K&M is the valve *that likes to be compared.*

Write for Bulletin CV-53

77th Anniversary...Oldest U. S. Pressure and Level Control Valve Manufacturer

K&M

KIELEY & MUELLER, INC.

diaphragm control valves

64 Genung Street
Middletown, New York

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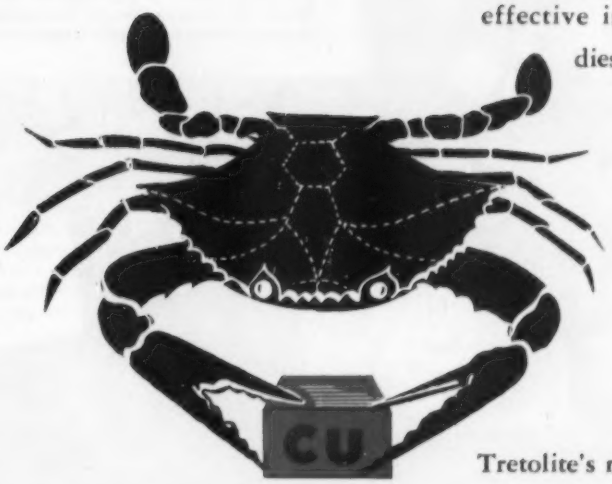
KUPLEX *

METAL DEACTIVATOR

Kuplex metal deactivator chelates copper and its compounds, preventing hydrocarbon deterioration caused by metal catalyzed oxidation. It is especially effective for the stabilization of gasolines, and is also effective in kerosines, jet fuels, diesel oils, burning oils and turbine oils.



Tretolite's many years of chemical manufacturing integrity assures refiners that Kuplex will be another high-quality Tretolite product.

* *A new Tretolite Company Product*

For samples and technical data, ask your Tretolite refinery engineer, or write to

TRETOLITE COMPANY

A Division of Petrolite Corporation
369 Marshall Avenue, St. Louis 19, Missouri
5515 Telegraph Road, Los Angeles 22, California

Chemicals and Services for the Petroleum Industry

DESALTING • DEMULSIFYING • CORROSION PREVENTIVES • SCALE INHIBITING • ASPHALT ADDITIVES • FUEL OIL ADDITIVES • WATER DE-OILING • PARAFFIN REMOVAL • PRODUCTION STIMULATION BACTERICIDES • METAL CONDITIONERS

KU-2

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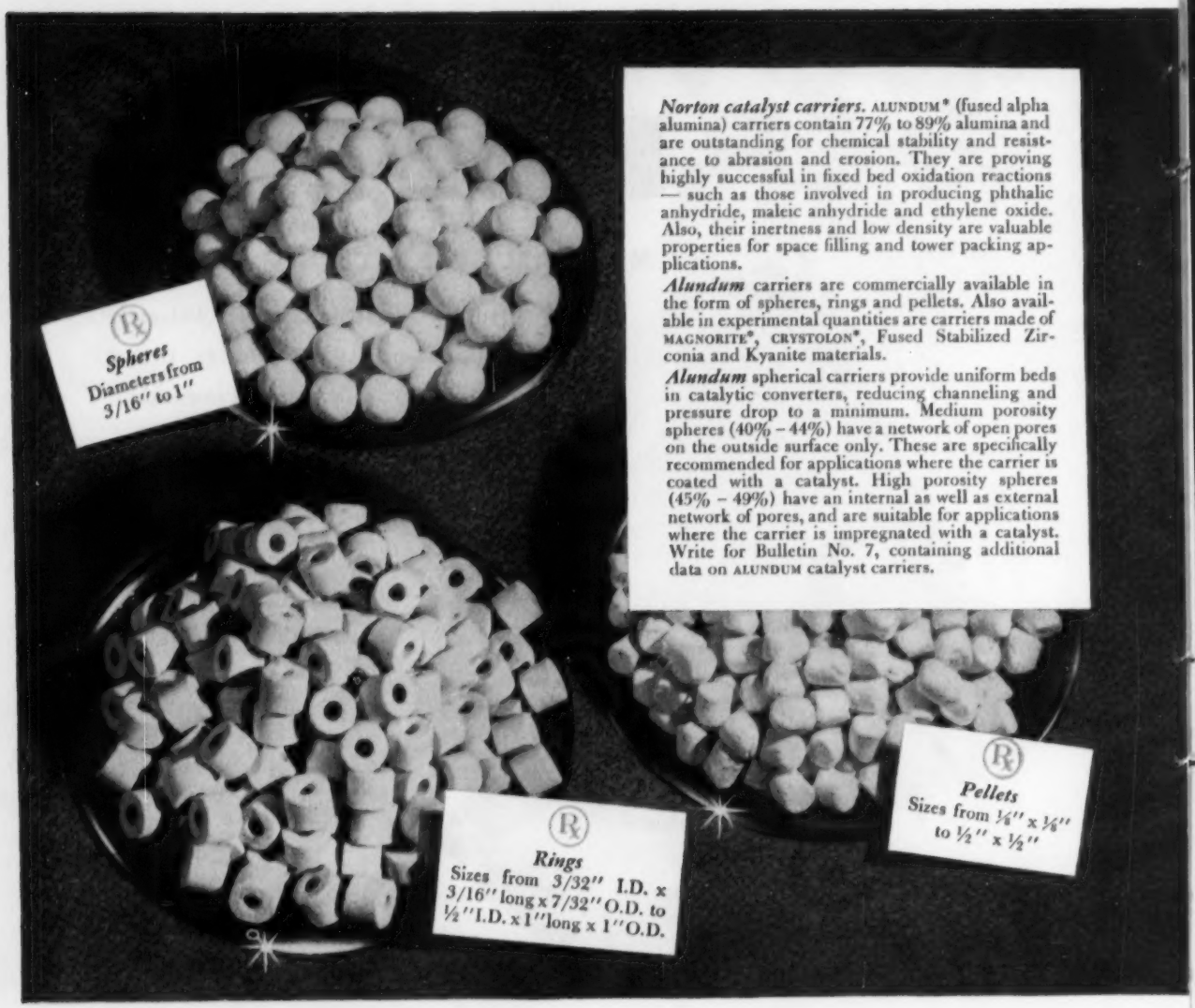


Norton catalyst carriers. ALUNDUM* (fused alpha alumina) carriers contain 77% to 89% alumina and are outstanding for chemical stability and resistance to abrasion and erosion. They are proving highly successful in fixed bed oxidation reactions — such as those involved in producing phthalic anhydride, maleic anhydride and ethylene oxide. Also, their inertness and low density are valuable properties for space filling and tower packing applications.

Alundum carriers are commercially available in the form of spheres, rings and pellets. Also available in experimental quantities are carriers made of MAGNORITE*, CRYSTOLON*, Fused Stabilized Zirconia and Kyanite materials.

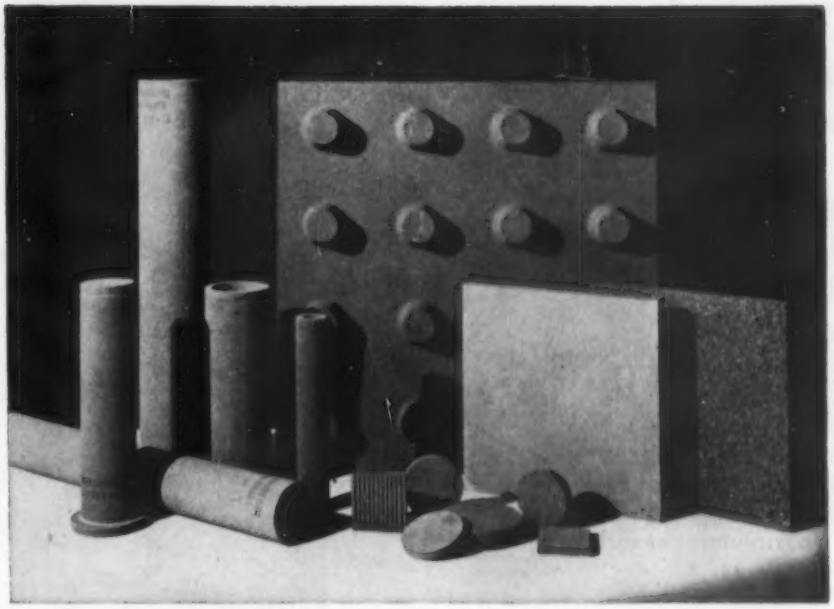
Alundum spherical carriers provide uniform beds in catalytic converters, reducing channeling and pressure drop to a minimum. Medium porosity spheres (40% – 44%) have a network of open pores on the outside surface only. These are specifically recommended for applications where the carrier is coated with a catalyst. High porosity spheres (45% – 49%) have an internal as well as external network of pores, and are suitable for applications where the carrier is impregnated with a catalyst. Write for Bulletin No. 7, containing additional data on ALUNDUM catalyst carriers.

Rx for more profitable processing

Norton engineered and prescribed refractories are proved aids to better, lower cost production

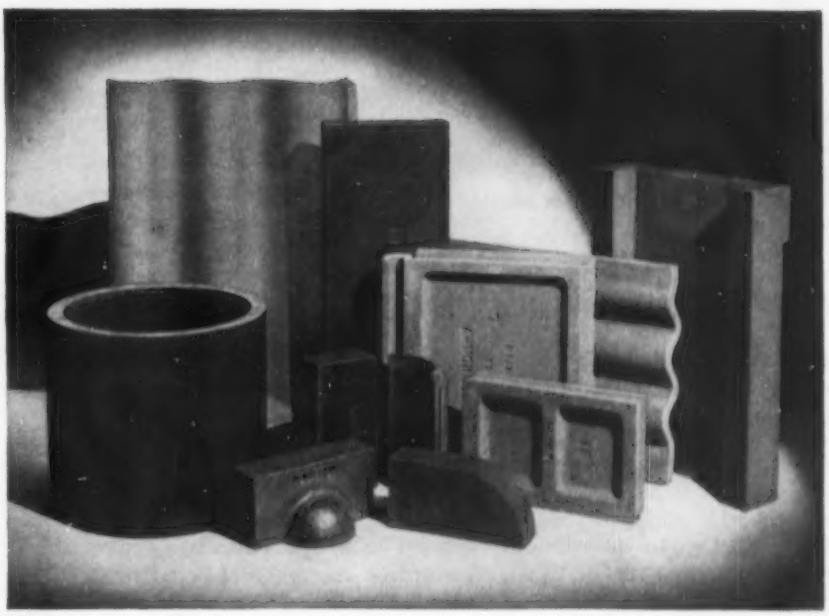
Backed by over 50 years of experience in electrochemical refining, Norton produces refractories whose purity and properties are carefully controlled and consistently duplicated. These refractories are *engineered and prescribed* to give you the best possible Rx — the most effective combination of physical characteristics, plus thermal, chemical and electrical properties — for your particular applications.

Chemical engineers are finding these Rx's of immense practical value in widely varying processes. Whatever your own processes may be, it will pay you to learn more about the many advantages of Norton refractories. Just a few products in this complete, top-quality line are described here. For complete details, and expert technical aid, call in your Norton Refractories Engineer. Meanwhile, write direct for the illustrated bulletins, mentioned in this advertisement, that cover your requirements. NORTON COMPANY, 468 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Can.



Norton porous mediums come in plates, tubes, discs and diaphragms, engineered to fit your filtering, diffusing or aerating requirements. All have uniform porosity, in the size and open-pore ratio you need. Made of ALUNDUM material that is chemically stable and strong, their resistance both to acid and alkaline conditions gives them extra long life. Norton seamless porous tubes have the advantage, unusual in tubes, of uniform porosity over their entire area — permitting constant air or liquid pressure and enabling uniform backwashing to do more thorough cleaning.

Typical applications are filtering water or solvents; cutting oils, wine and other liquids; reclaiming cleaning fluids; handling industrial oil wastes; chlorination, carbonation and other gas diffusion applications. Bulletin No. 140 tells you more about Norton ALUNDUM porous mediums.



Norton refractory shapes for reaction furnaces come in bricks, plates, tubes and blocks, made of ALUNDUM, CRYSTOLON, MAGNORITE and Fused Stabilized Zirconia refractory materials. The development of Fused Stabilized Zirconia is a typical example of how Norton aids you in utilizing higher temperatures for greater efficiency and output. Norton was the first to bring this valuable material out of the experimental stage into commercial production. Now it is used in many processes.

No other refractory is so chemically stable at such high temperatures under both oxidizing and reducing conditions. In gas synthetic processes, furnaces lined with it have withstood temperatures approaching 4700°F for long periods. Its low thermal conductivity (6.2 BTU in dense shapes at 2000°F) and its high electrical conductivity at high heat are other important properties, all of which are described in Bulletin No. 1741.

Norton electric furnace shapes and laboratory ware

Norton electric furnace refractories — cores, tubes and muffles — are made of ALUNDUM or CRYSTOLON materials. ALUNDUM shapes, composed of 99% pure fused alumina, are characterized by great stability, chemical inertness, excellent thermal conductivity and good electrical insulation qualities. CRYSTOLON shapes, for use under more limited conditions, combine high thermal conductivity with resistance to heat shock. Bulletin No. 458 tells how to construct electrical furnaces for the laboratory.

Norton ALUNDUM laboratory ware, available at your laboratory supply house, offers many properties important to development, experimental or analytical work. It is chemically stable, stands temperatures up to 1900°C and is easy to clean. For filtering, it comes in four degrees of permeability. Bulletin No. 793 gives you the whole story.

NORTON

REFRACTORIES

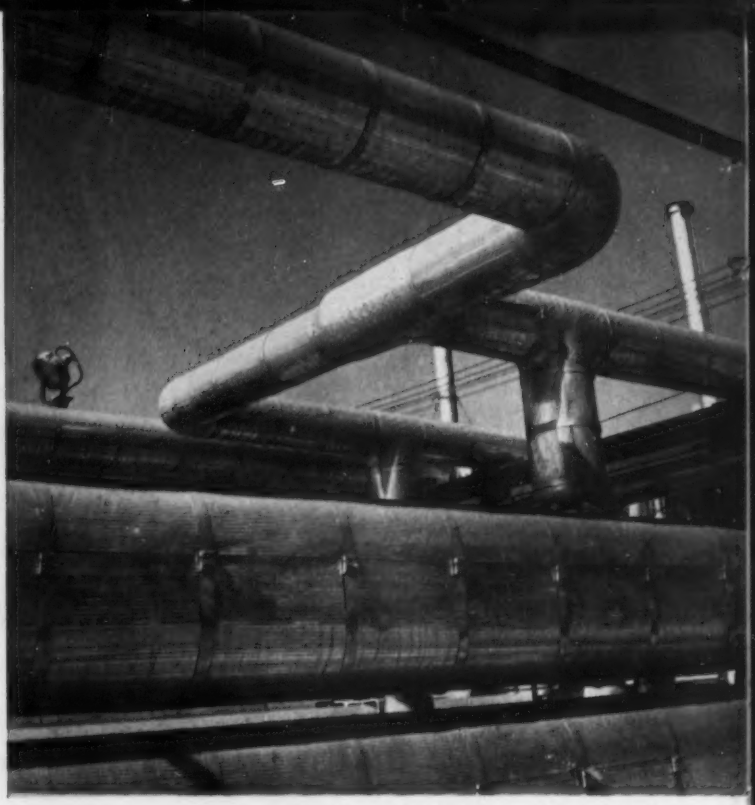
Engineered . . . Rx . . . Prescribed

Making better products . . . to make your products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

How Olin Mathieson Uses Childers Jacketing For Insulated Lines

Jacketing problems at new plant ranged from covering tall towers to irregularly-shaped heat exchangers. Read how aluminum jacketing solved these problems.



More than 244,000 square feet of Childers .006″ Jacketing and 35,000 square feet of heavy weight Childers Jacketing was used in this new Olin Mathieson plant to weatherproof insulated lines, towers and vessels. Close-up above shows how aluminum jacketing was applied with strapping and seals.

Low first-cost, long life, and easy installation were the big reasons Olin Mathieson Chemical Corporation used Childers Aluminum Jacketing for outdoor insulated lines in their new Brandenburg, Ky., petrochemical plant.

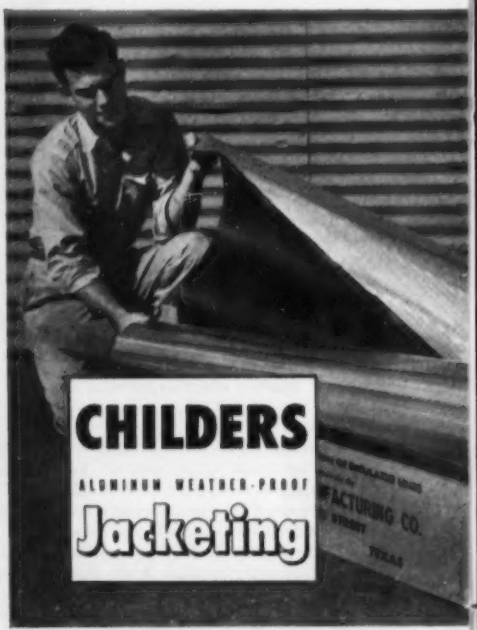
Mathieson used Childers standard weight Jacketing on their insulated lines. Heavier weights of Childers Jacketing were used on high towers and vessels where a stiffer material was needed to support the vertical weight of the jacketing.

Engineers report that Childers Jacketing is inexpensive to apply. It comes in easy-to-handle rolls 4 ft. wide and 100 ft. long. Just pliers and a pocketknife are the only tools needed to apply. And because the jacketing is aluminum it needs no painting . . . stays clean and new looking even after years of service.

Childers Jacketing is easily removable, too. Just remove the strapping and jacketing can be taken off for inspection of the lines. Then same jacketing can easily be put back on the insulated line.

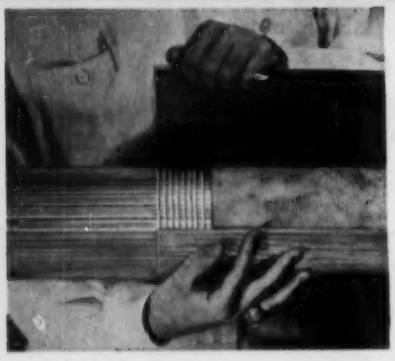
Immediate shipment from our large factory stocks can eliminate costly delays in construction or plant improvement schedules.

Try this low-cost protection in your plant. Write today for engineering data and information. You can order a 400 sq. ft. roll to test on one of your insulated lines. No obligation. Address: Childers Manufacturing Company, Department PR-28, 3620 West 11th St., Houston, Texas.



Each roll of Childers Jacketing comes individually packed like this in a heavy corrugated carton. Rolls are 4 ft. wide. With moisture barrier attached they are 100 ft. long; without moisture barrier they are 200 ft. long. They are well protected for field storage if kept dry. Individual boxes are light enough for one man to handle. (Adv.)

Only Childers Jacketing Offers *LAP-SEAL*



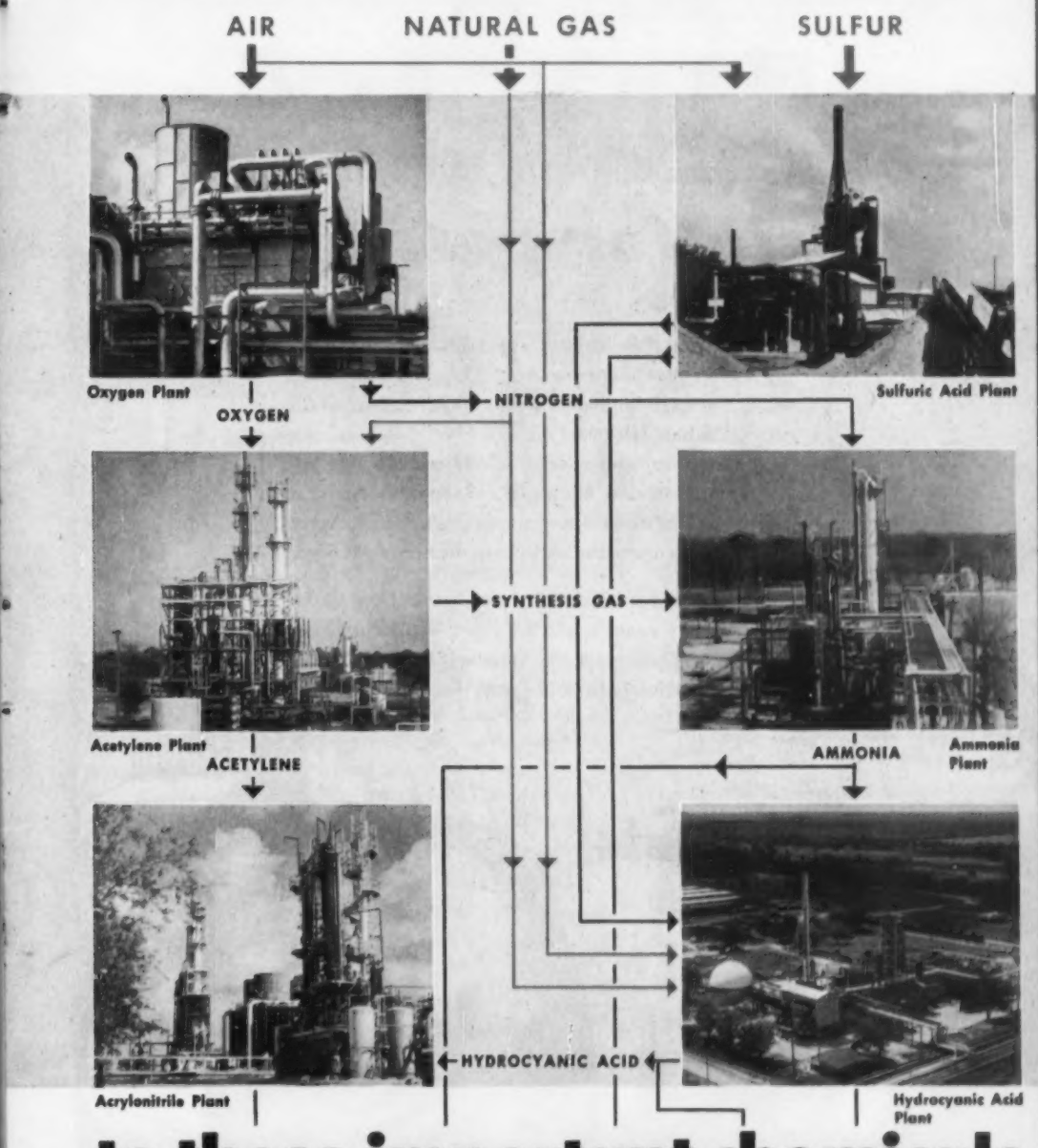
LAP-SEAL **is a series of eight ribs rolled into the underlapping edge of the jacketing.**

LAP-SEAL **makes more positive weather seal.**

LAP-SEAL **saves labor—2″ ribbed edge eliminates measuring for circumferential lap.**

LAP-SEAL **(patent applied for) is an exclusive "plus" available on all Childers Jacketing at no extra cost.**

From these raw materials...



to these important chemicals

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CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

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Cable Address: Chemiconst, New York • Technical Representatives: Cyanamid Products Ltd, London South African Cyanamid (Pty) Ltd., Johannesburg

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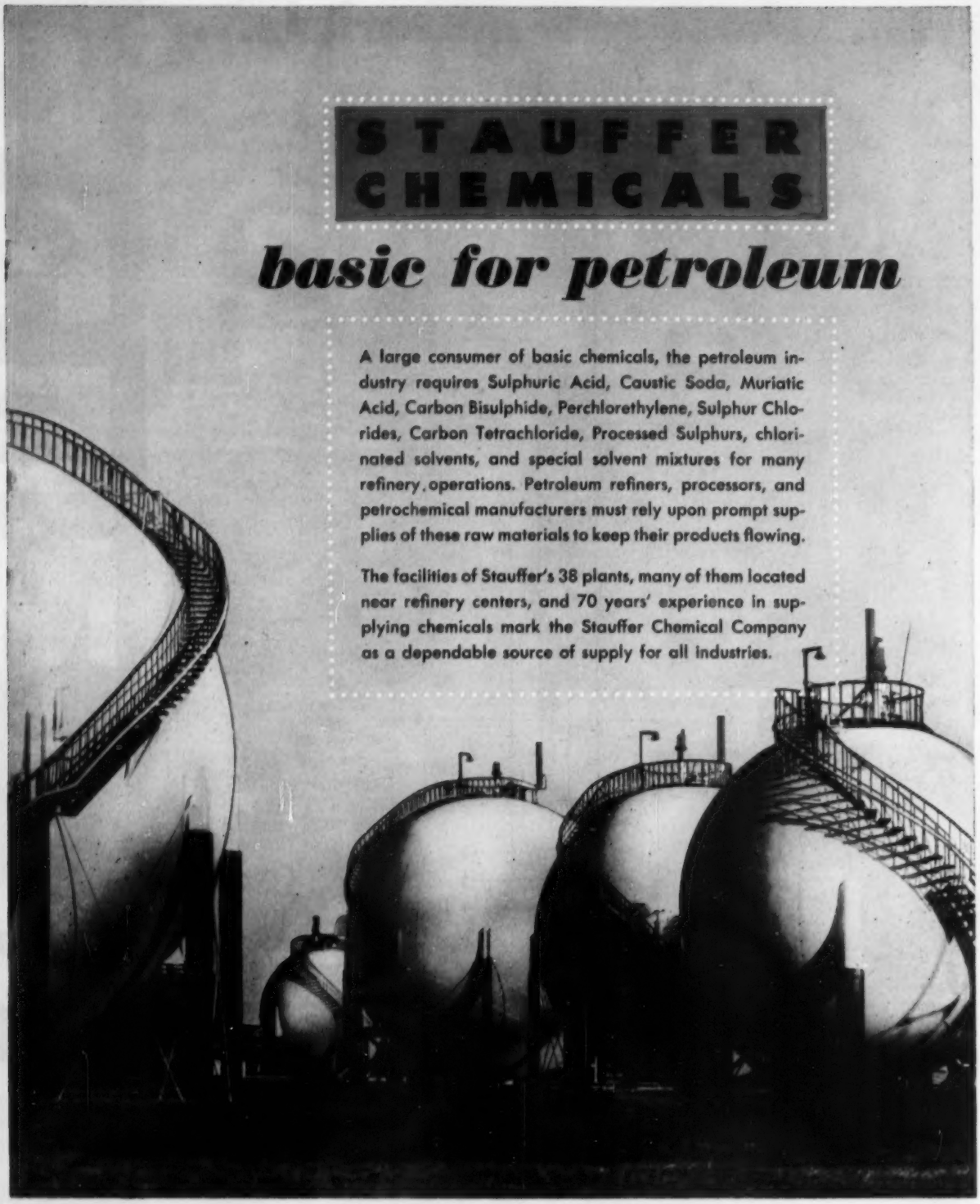
STAUFFER
CHEMICALS
basic for petroleum
A large consumer of basic chemicals, the petroleum industry requires Sulphuric Acid, Caustic Soda, Muriatic Acid, Carbon Bisulphide, Perchlorethylene, Sulphur Chlorides, Carbon Tetrachloride, Processed Sulphurs, chlorinated solvents, and special solvent mixtures for many refinery operations. Petroleum refiners, processors, and petrochemical manufacturers must rely upon prompt supplies of these raw materials to keep their products flowing.
The facilities of Stauffer's 38 plants, many of them located near refinery centers, and 70 years' experience in supplying chemicals mark the Stauffer Chemical Company as a dependable source of supply for all industries.

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STAUFFER CHEMICALS

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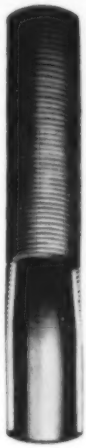
Slashing Costs With Trufin
—Number 9 of a Series

SAVE 22%



on Initial Heat Exchanger Cost

—with WOLVERINE TRUFIN* Type S/T

A net saving of 22% in condenser tube costs has been realized by one of the nation's largest petrochemical companies. The secret? Wolverine Trufin Type S/T!

In deciding to modernize and to step up capacity of its butylene concentration unit, nothing was left to chance. Comparison tests were run on both finned and prime surface units and bids were requested. The units designed around Trufin Type S/T were 22% lower in initial costs than prime surface units of the same capacity.

Although less expensive and smaller in size, the Trufin units after side-by-side comparison tests for one year, matched in every way the performance of their larger prime surface counterparts.

You, too, can cash in on equally large savings in your plant through use of Wolverine Trufin Type S/T condenser tube. Trufin, with its integral fins extruded directly from the tube wall, has over twice the outside surface area of prime surface tube. As a result, less tube is required—which in turn means smaller shells, headers and baffles and less maintenance.

Trufin is mechanically interchangeable with prime surface tube. The tube wall at the plain end is heavier than the wall at the finned section, giving greater rigidity and maximum protection at the header.

Plan now to utilize Trufin's full abilities—increase heat duty—save space—and dollars! To get the facts—write for your copy of the Trufin Opportunity Book. It's packed with actual Trufin case histories and valuable design information. Wolverine Tube, 1437 Central Avenue, Detroit 9, Michigan.

*REG. U.S. PAT. OFF.

WOLVERINE TUBE
DIVISION OF CALUMET & HECLA, INC.
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA • SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT., 13 E. 40TH ST., NEW YORK 16, N. Y.

Take a cue from CORROSION

Corrosion—the bugaboo of refinery and petrochemical plants—is the big reason Wolverine offers condenser tubes in such a wide variety of metals and alloys. In addition, concrete on-the-spot help is offered by Wolverine through the use of its expanded Field Engineering Service.

Here are typical questions asked FES recently:

Q Does Wolverine have a tube that can withstand simultaneous inside and outside attacks from two different types of corrosion?

A We certainly do. Wolverine Duplex Condenser Tube consists of inner and outer tubes of different metals mechanically bonded together. Combinations of copper, copper-base alloys, aluminum or steel can be used to withstand different types of corrosion on either side.

Q Heavy concentrations of ammonia are causing frequent failure of our condenser tubes. What can we do?

A Retube with Wolverine steel condenser tube. It is because of just such cases as this that Wolverine manufactures tubing in a wide range of alloys in copper, aluminum and electric-welded steel. Customers must have a choice because **no one alloy can meet all conditions.**

*REG. U.S. PAT. OFF.

Q How can we overcome erosion in our salt water installations?

A Wolverine condenser tubes of 90-10 Cupro-Nickel can help overcome this condition. In addition to the right alloy Wolverine also insists, through rigid quality control, that its tubing be uniform and free from scratches, pits and inclusions. Such defects can give erosion its initial entry and speed tube failure.

Q We want to reduce weight in our sour gasoline condensers. Could we use aluminum condenser tubes?

A You bet! Wolverine 3S alloy aluminum tube is made to order for such operations. In addition to lightness you will also get high heat conductivity and find it easy to fabricate.

Don't let corrosion steal your tubing dollars. Wolverine's Field Engineering Service is ready at all times to help solve your problems. Call on them—today. Write, too, for your copy of the Wolverine Condenser Tube Book.

WOLVERINE TUBE
DIVISION OF CALUMET & HECLA, INC.
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes
EST. 1910

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario

The WOLVERINE Line Up

1. WOLVERINE TRUFIN* TYPE S/T
The industry's only integral finned tube. (In copper, copper-base alloys, aluminum, electric-welded steel.)

2. PRIME SURFACE CONDENSER TUBE
In three metals and their alloys.

3. DUPLEX TYPE S/T CONDENSER TUBE
A liner of one metal, a finned exterior of another.

4. PRIME SURFACE DUPLEX CONDENSER TUBE
To combat two different corrosive attacks.

5. U-BEND CONDENSER TUBE
The only direct mill source . . . palletized!

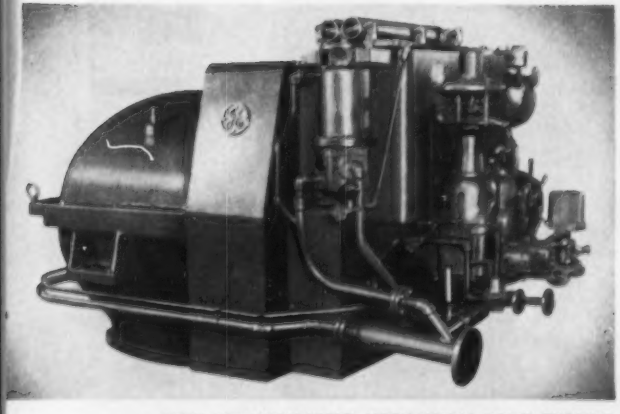
PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA • SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT., 13 E. 40TH ST., NEW YORK 16, N. Y.

TURBINES FOR
HIGH-SPEED COMPRESSORS

OIL DAM IN UPPER BEARING HALF, located at pencil point, restricts oil flow around shaft, building up a pressure pad as shown at left. As turbine gains speed, oil pressure increases and forces shaft down into ample surfaces of lower bearing liner, above right, assuring stability at high speed.

Large pressure-pad bearings add years of life to G-E high-speed turbines



TYPE DRV HIGH-SPEED MECHANICAL-DRIVE TURBINE

To provide longer, more reliable service, all G-E high-speed turbines incorporate large pressure-pad bearings. The generous surfaces of the bearings assure low unit loading for ample lubrication and minimum wear during start-up.

AS TURBINE SPEED INCREASES, the viscous pump action of the shaft carries oil into the cavity, forming a pressure pad. The shaft is thus forced into the lower bearing half, assuring high unit loading. This minimizes the possibility of vibration, with its detrimental effect on bearing and packing life.

THIS IS ONLY ONE OF MANY DESIGN FEATURES that make a G-E high-speed turbine your most reliable drive for compressors and blowers. For more information, contact your nearest G-E Apparatus Sales Office or write to General Electric Company, Schenectady 5, N. Y. In Canada, contact Canadian General Electric Company, Limited, Toronto. 241-1

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WILFLEY ACID PUMPS handling

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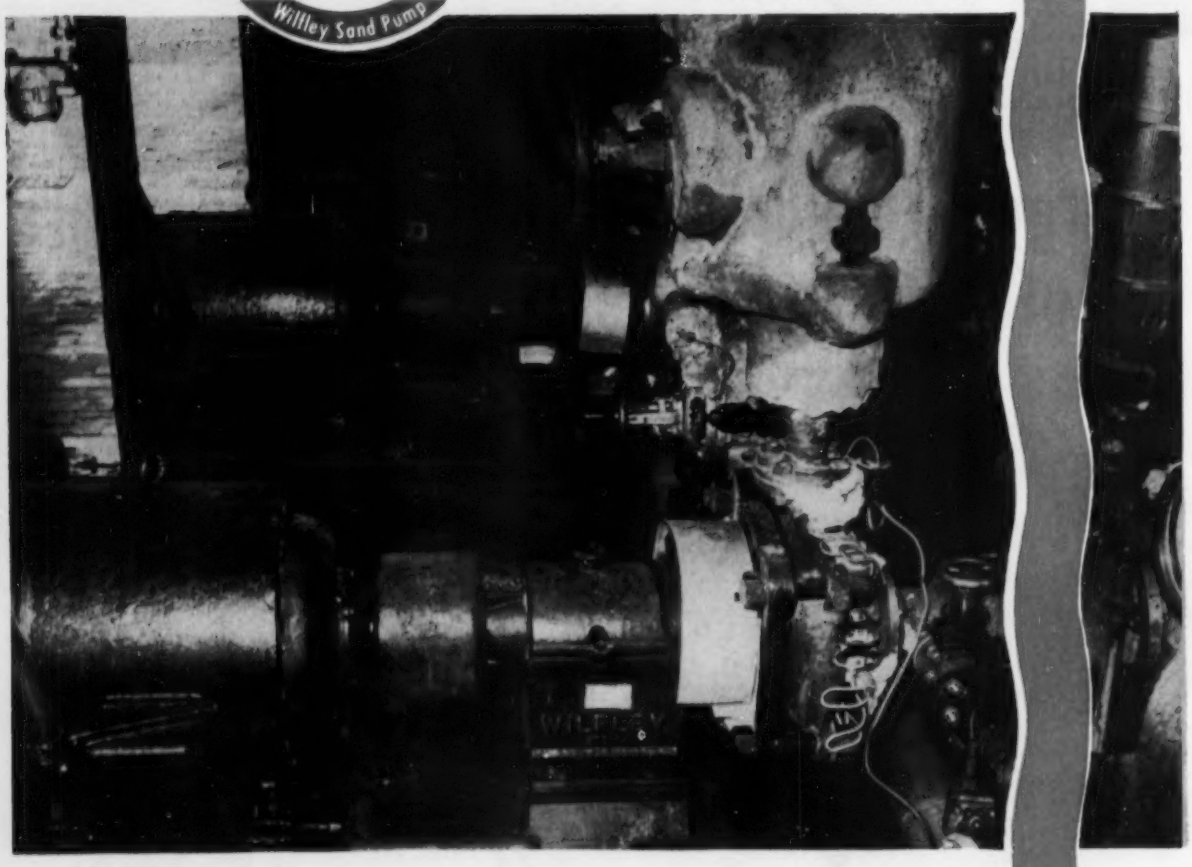
These highly efficient Wilfley Acid Pumps step up production and reduce pumping costs in this modern chemical plant. Wherever installed, Wilfley Pumps operate without attention, delivering trouble-free performance on 'round-the-clock schedules. Available with pumping parts of the machinable alloys as well as plastic to meet all requirements. Individual engineering on every application. Write or wire for complete details.

Wilfley Acid Pump
"COMPANIONS IN ECONOMICAL OPERATION"
Wilfley Sand Pump

Photo shows drilling tower pumps (steam jacket partially removed).



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New York Office: 1775 Broadway, New York City

to remove

H_2S

CO_2

use

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Diethanolamine

high purity
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H_2O

use

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Triethylene Glycol

high purity
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NITROGEN DIVISION ALLIED CHEMICAL

Maximize the purity of your gas stream, and minimize corrosion problems by using Nitrogen Division gas-treating chemicals. Free of unwanted chemical impurities – chlorides and acids – these products are consistently above standard purity specifications.

Call or write today for samples and quotations. Ask too for technical service to help adapt these high purity chemicals to your process.

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Allied Chemical

Maximize the purity of your gas stream, and minimize corrosion problems by using Nitrogen Division gas-treating chemicals. Free of unwanted chemical impurities – chlorides and acids – these products are consistently above standard purity specifications.

Call or write today for samples and quotations. Ask too for technical service to help adapt these high purity chemicals to your process.

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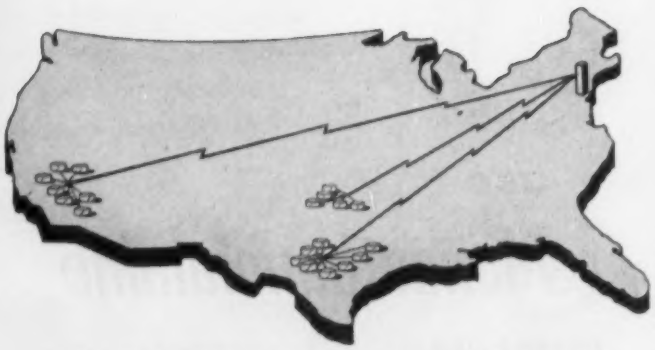
Anhydrous Ammonia • Ammonia Liquor • Ammonium Sulfate • Sodium Nitrate • Methanol • Urea
Ethanolamines • Ethylene Oxide • Ethylene Glycols • Formaldehyde • Nitrogen Tetroxide
Nitrogen Solutions • U.F. Concentrate—85 • Fertilizers & Feed Supplements

YOU SELECT THE TANK —

THE versatile Shand & Jurs TELEPULSE system quickly and accurately gages liquid level of any tank within the range of modern communications systems. No matter how distant a tank, S&J TELEPULSE will give you its liquid level in half a minute. TELEPULSE performs remote gaging electrically, automatically and safely; gives you reliable, timely information quickly; eliminates transmittal errors and hazards to personnel; and saves on gaging costs. TELEPULSE is an investment that could pay you large dividends.

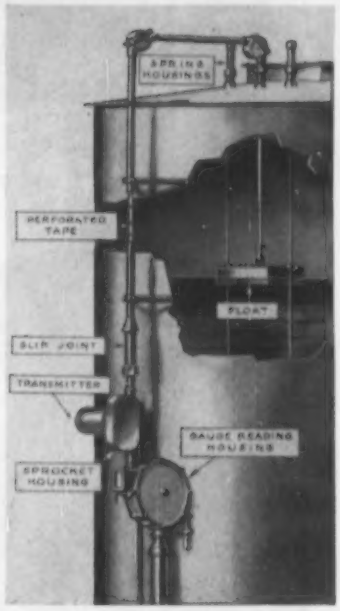


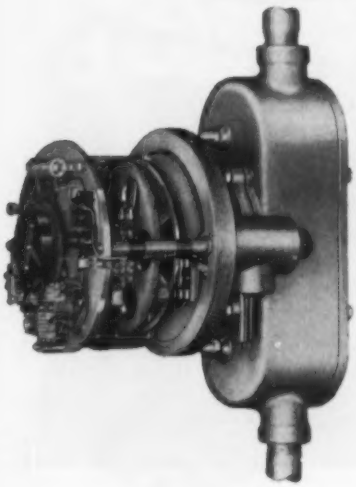
The S&J TELEPULSE system is neither delicately intricate nor over costly. Incorporating time-tested, standard equipment of both the telegraph and dial telephone, TELEPULSE is exceptionally versatile for installation with existing leased wire, radio, or micro-wave communications systems. With dual use in view, a new system combining TELEPULSE and communications may be installed without the least complication. TELEPULSE is versatile for installation, dependable and precise in operation. It will bring you a new concept of remote gaging, never thought possible before.

For complete information about the new S&J TELEPULSE system write the factory or nearest branch listed at the right for Bulletin T-455.

Telepulse will accurately Gage its liquid level in 30 seconds!

The S&J TELEPULSE system operates in conjunction with time proven S&J Float Gages mounted on each tank for which remote gaging is desired. A typical installation of an S&J Float Gage in the TELEPULSE system is shown at the right. The gage itself has long been a standard and widely used unit for continuous measurement of liquid depths and is accurate to within ⅛" of tank liquid level. Those S&J Float Gages already in operation are easily adapted for incorporation into the new S&J TELEPULSE system.





The transmitter of the S&J TELEPULSE system is installed with its sprocket housing in the gage tape pipe and is coupled directly to the perforated gage tape by a sprocket wheel. As the liquid level in a tank moves up and down, so does the gage float and tape. The tape turns the sprocket wheel which in turn rotates the shaft of the transmitter through proper gearing. Therefore the mechanism in the transmitter corresponds to the liquid level in the tank at all times.

There are at present two principal variations of the S&J TELEPULSE system. Each is adapted to different remote gaging requirements. For long distances, more than 5 to 10 miles, and for large groups or several groups of tanks, the ST-8300 shown at right above is used. For short distances, or local requirements, where spacing and distances are such as to justify direct wire connections to each tank, the ST-8310 system is shown. Either of these systems will deliver the optimum in performance, dependability, and economy, depending on the requirements of a particular remote gaging situation.

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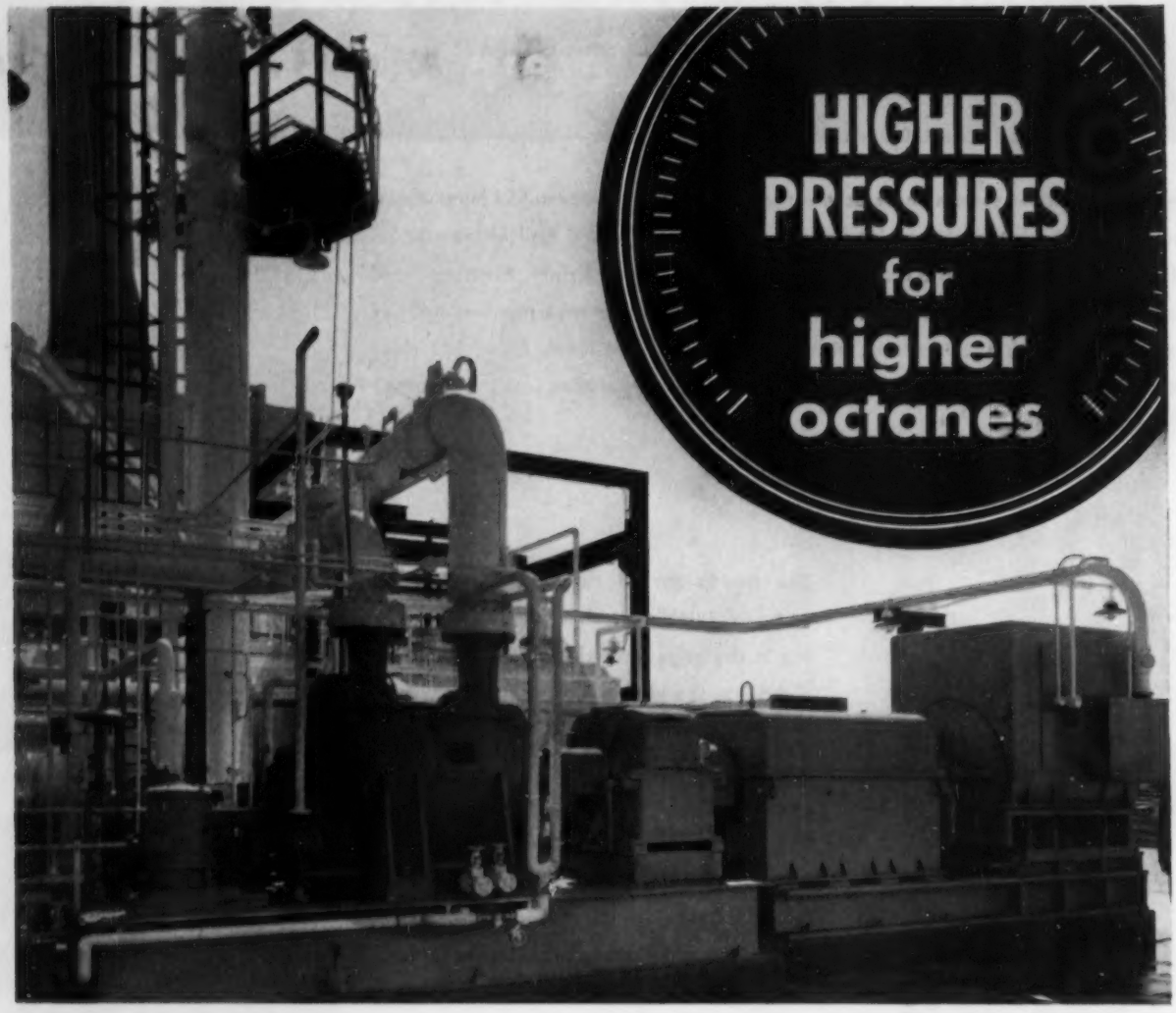

There's no refinery compression job today that can't benefit from the proved economy and dependable performance of modern I-R compressors — available in types and sizes to meet every process requirement. Your I-R representative will be glad to help you work out the best solution to your particular problems.

I-R compressor design keeps pace with latest advances in refining technology at Union Oil Company

IN the new catalytic reforming processes for production of high octane gasoline, large volumes of low-density hydrocarbon gas must be compressed to pressure levels of up to 700 psig. These difficult requirements are easily met with Ingersoll-Rand multi-stage centrifugal compressors of the "barrel" or double-case design, as shown above.

For instance, in catalytic reforming service at the Union Oil Company's Oleum refinery, the above I-R centrifugal unit compresses 2670 cfm of 85% hydrogen gas from 473 psia to 669 psia. This 6-stage, double-case compressor, with pressurized oil shaft seals, is driven by a 3500 hp, 1750 rpm motor through a 4.55-to-1 speed increasing gear. Outer barrel is of forged steel and the removable inner casing is horizontally split to permit inspection or removal of the rotor.

12-291

Ingersoll-Rand

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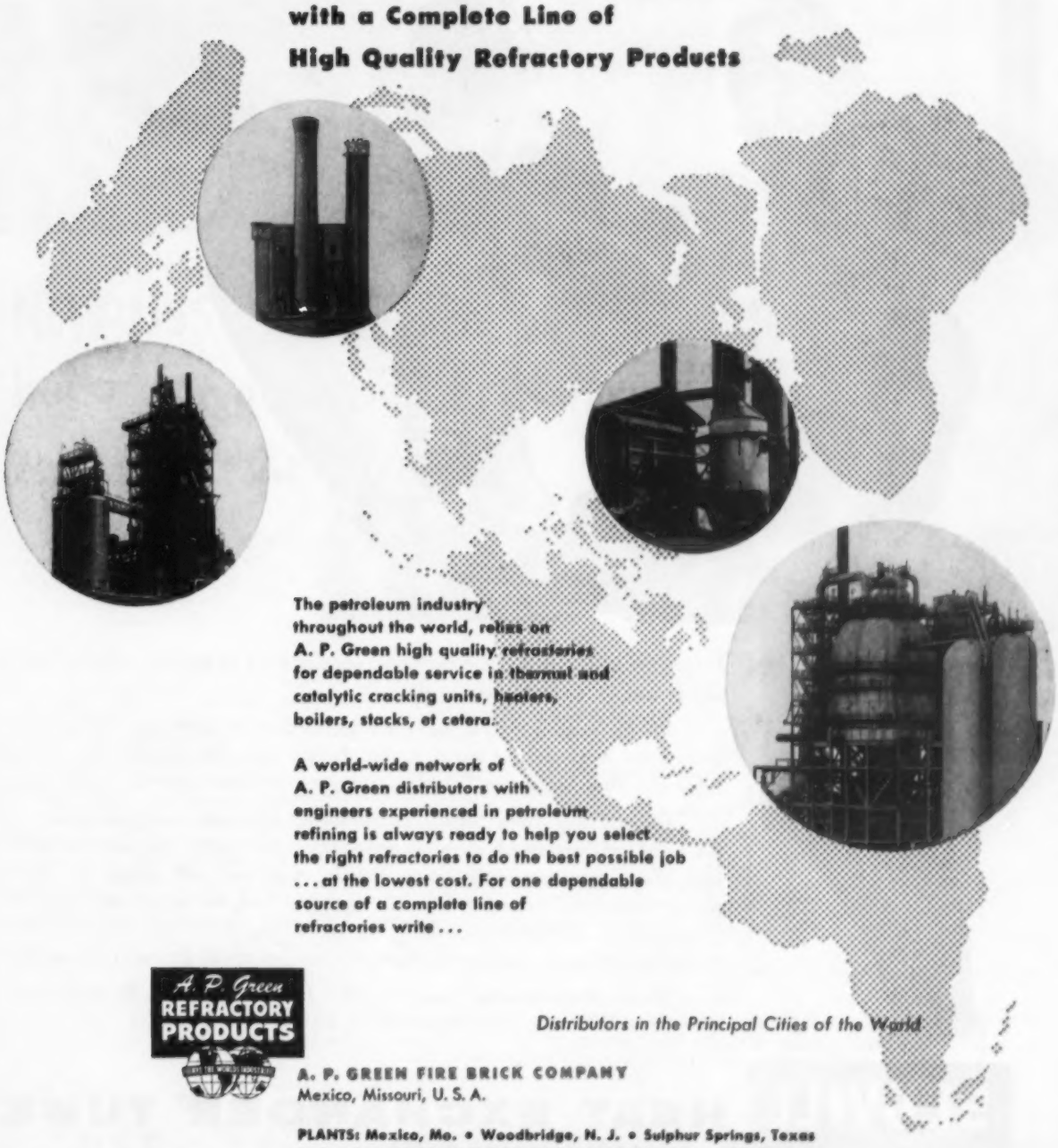
COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO-BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • DIESEL AND GAS ENGINES

throughout the world...

A. P. GREEN

Serves the Petroleum Refining Industry with a Complete Line of High Quality Refractory Products



The petroleum industry throughout the world, relies on A. P. Green high quality refractories for dependable service in thermal and catalytic cracking units, heaters, boilers, stacks, et cetera.

A world-wide network of A. P. Green distributors with engineers experienced in petroleum refining is always ready to help you select the right refractories to do the best possible job ... at the lowest cost. For one dependable source of a complete line of refractories write ...

A. P. Green REFRACTORY PRODUCTS

Distributors in the Principal Cities of the World

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In England: **LIPTAK FURNACE ARCHES, LTD.** *London, England*

For more data on advertised products, use Readers' Service Cards, last page.

Evenly matched or not...

there's enough difference to make all the difference

Before the bout, two fighters may look equally good to the fans. After a round or two, the differences begin to show up.

It's the same with heat exchanger tubes. They all start out looking pretty much alike, but under the test of day-in, day-out operation, Scovill Phosphorized Admiralty Heat Exchanger Tubes have consistently shown superior performance.

Hot-extrusion from Scovill Continuous-Cast billets means uniformity in the metal, uniformity of chemical composition and grain structure, uniformly high phosphorus content. It means sounder metal—smooth, dense, free from pits or porosity. These—plus Scovill's unrivaled Technical Application Services—are, indeed, differences that make *all* the difference in economical, uninterrupted service under tough operating conditions. Let us tell you more about them.

Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.

SCOVILL **HEAT EXCHANGER TUBE**

Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Muntz Metal • Naval Brass • Red Brass, 85% • Deoxidized Copper
Arsenical Copper • Copper Nickel, 10% & 20% • Cupro Nickel, 30% • Aluminum Brass • Aluminum Bronze, 5% • Duplex Tube

39C58

For more data on advertised products, use Readers' Service Cards, last page.

WELDMENTS of "T-1" Steel—made with AWS 12015 low hydrogen coated electrodes and without pre- or post-heating — develop the full 90,000 psi yield strength. As a result, lightweight designs are completely safe and reliable.

NEW USS "T-1" STEEL has great potential for reducing cost of pressure vessels

You've heard of Operation "T-1." You've heard how those dramatic tests proved that, when and if higher design stresses are permitted, USS "T-1" constructional alloy plate steel will make possible larger, stronger pressure vessels, vessels that can be built more easily and at lower over-all cost. As a result of Operation "T-1," several major pressure vessel fabricators have requested approval from the ASME to use USS "T-1" Steel in unfired pressure vessels. Why? For mighty good reasons:

"T-1" Steel has a very high yield strength – 90,000 psi minimum – three times that of conventional plate steels now used in pressure vessels. Yet it is extremely *tough* and can withstand high stresses and pressures even at temperatures far below zero. What's more, USS "T-1" Steel remains strong at *high* temperatures up as high as 900 degrees F.

Yet, "T-1" Steel is easy to fabricate. It can be drilled, machined, or cold formed, and welded or flame-cut *without* pre- or post-heating. **"T-1" can make pressure vessels . . .**

LARGER. For a given pressure and shell thickness, the *radius* of a vessel may be increased in direct proportion to the ratio of working stresses. Result: more storage capacity at lower cost.

STRONGER. For a given radius and shell thickness, the *pressure* may be increased in proportion to the ratio of working stresses. Result: vessels for higher pressures at lower cost.

LIGHTER, EASIER TO BUILD. For a given pressure and radius, the shell thicknesses may be reduced, thus permitting larger vessels to be fabricated *without stress relief*. Result: lower fabrication cost.

United States Steel, Room 4899
525 William Penn Place, Pittsburgh 30, Pa.

☐ Please send me your booklet "United States Steel presents T-1" which contains the full story of "T-1" steel.

☐ Have your representative get in touch with me.

Name .....

Address .....

City ..... State .....

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

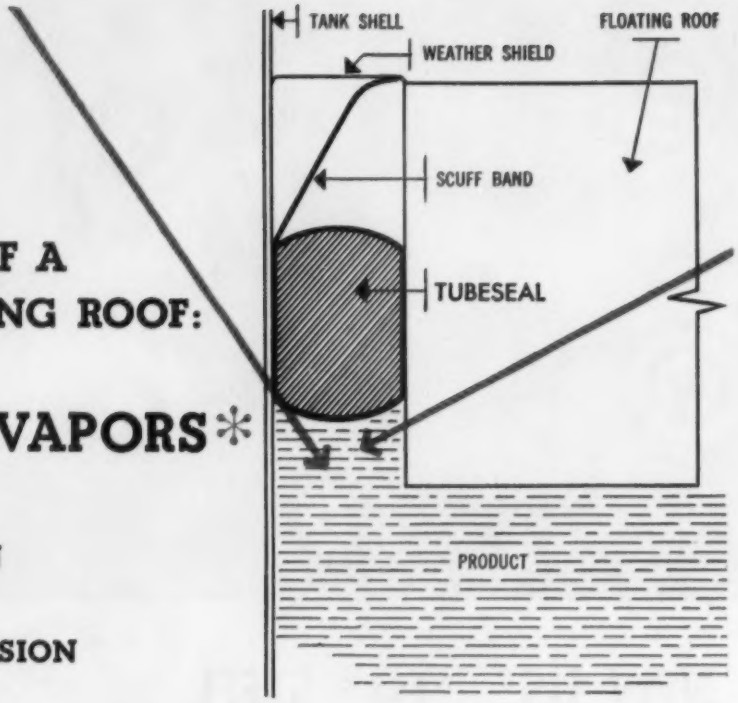
USS

UNITED STATES STEEL

THE SECRET OF A GOOD FLOATING ROOF:

NO ROOM FOR VAPORS*

*NO EVAPORATION
NO FIRES
MINIMUM CORROSION



Because there is no space in a HAMMOND TUBESEAL FLOATING ROOF, where vapor can form, jet fuels and other volatile products can be stored with assurance that evaporation and fires cannot take place and further that corrosion will be kept to a bare minimum.

THE HAMMOND TUBESEAL

The most efficient and positive seal known: no moving parts · no mechanical maintenance · climate proof · non-corrodible · can operate to bottom of tank or above the top · no vapor space below the seal · entire circumference has tight seal under pressure at all times.

LICENSES AVAILABLE

The makers of TUBESEAL believe that its unique safety and economy factors should be allowed to benefit the broadest possible section of the petroleum industry. For that reason HAMMOND IRON WORKS will license its use on a non-exclusive basis. For further information write to:

HAMMOND IRON WORKS,
Warren, Pa.

ask for Bulletin TS

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HAMMOND TUBESEAL COSTS NO MORE IN THE FIRST PLACE

CHEAPER OVER THE YEARS

HAMMOND
IRON WORKS
WARREN and BRISTOL, PA. • PROVO, UTAH
CASPER, WYO. • BIRMINGHAM, ALA.

● Patent applied for

NEED EXTREME DRYNESS?

ALCOA Activated Alumina dries to lower dew points than other commercial adsorbents

TYPICAL PROPERTIES
OF DESICCANT GRADES ALCOA ACTIVATED ALUMINAS

CHEMICAL ANALYSIS, %	F-1	F-3	F-5	F-6	H-151
Al_2O_3	92	92	77	88	85
Na_2O	0.80	0.80	0.70	0.76	2.0
Fe_2O_3	0.12	0.12	0.10	0.11	0.15
SiO_2	0.09	0.09	0.08	0.08	6.3
Loss on Ignition 1100°C (2012°F)	6.8	7.2	12.4	8.5	6.2
$CaCl_2$	.....	.....	9.3	.....	.....
$CoCl_2$	.....	.....	.....	2.0	.....
PHYSICAL PROPERTIES					
Form	Granular	Granular	Granular	Granular	Ball
Surface Area, meters²/g	210	200	.....	200	350
Bulk Density, Packed, lb/ft³	55	55	60	57	55
Bulk Density, Loose, lb/ft³	50	50	55	52	52
Specific Gravity	3.3	3.3	.....	.....	3.1-3.3
Dynamic Sorption*	13-15	11-13	18-23	13-15	21-23
Crushing Strength†	55	55	.....	.....	60
Pore Volume, ml./g	0.25	0.25	.....	0.25	0.3
Pore Diameter, Å	40	40	.....	40	50
Static Adsorption at 60% Relative Humidity, %	13.0 (Min.)	11.0 (Min.)	.....	.....	20.0 (Min.)

The standard sizes for F grade alumina are ½" to ¼", ¼" to 8 mesh and 8 to 14 mesh. Other nonstandard sizes from 2" granules to 325 mesh powder are available. Activated Alumina H-151 is available in nominal ⅛" and ¼" diameter balls.

*Adsorption of moisture at 100% efficiency from air under isothermal conditions at 30°C and 84% relative humidity under dynamic flow of 7.5 cu ft/hr/lb *Activated Alumina—Its Properties and Uses.*
†Method of *Activated Alumina—Its Properties and Uses.*

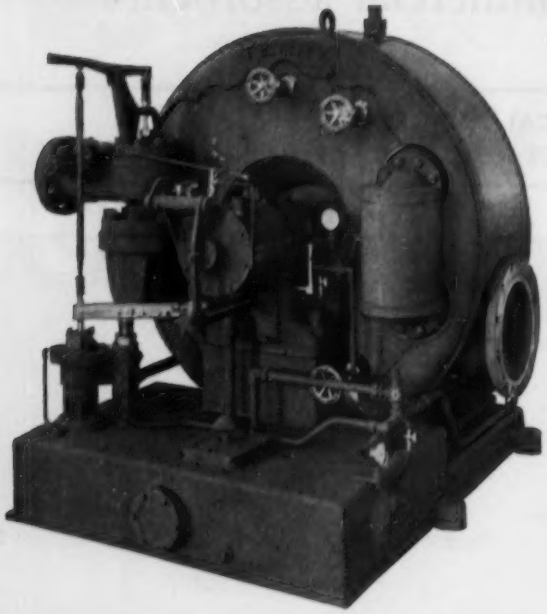
ALCOA* Activated Aluminas are among the most effective and efficient desiccants available for the dehydration of liquids and gases. Dew points as low as minus 100°F—and even lower—may be obtained, and under normal circumstances, ALCOA Activated Aluminas can be used for an almost indefinite number of drying cycles.

Besides their use for dehydration, ALCOA Activated Aluminas adsorb certain gases and vapors from gaseous mixtures and serve as catalysts and catalyst carriers. They are used in the liquefaction of gases, and for the maintenance of transformer and lubricating oils.

Let us tell you more about these efficient desiccants, and supply you with samples. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 717-J Alcoa Building, Pittsburgh 19, Pennsylvania.

For more data on advertised products, use Readers' Service Cards, last page.

TROUBLE-FREE TURBINE OPERATION STARTS HERE



Terry solid wheel turbines have become a symbol for dependable, trouble-free operation. The reason—simplicity and ruggedness of construction.

Take the rotor, for instance. It's a solid forging in which a series of semi-circular buckets is milled. There are no separate parts to loosen or work out. Since the only function of the blades is to form a series of pockets, any wear which might occur would not materially affect horsepower or efficiency.

It is impossible for the blades to foul. They have large clearances and are further protected by the projecting rims at the sides of the wheel. As the side clearances are also very large, end play can do no harm.

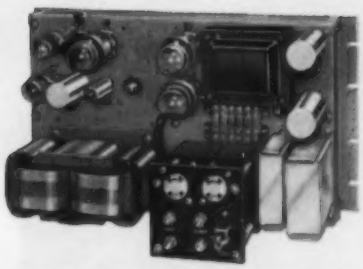
Simplicity outside too—as you can see from the photograph of the 1500 HP at 3500 RPM solid wheel turbine above. This turbine is equipped with an oil relay governor and forced feed lubrication to the bearings.

For more about these *work horses of industry*, send for a copy of bulletin S-116. No cost or obligation.

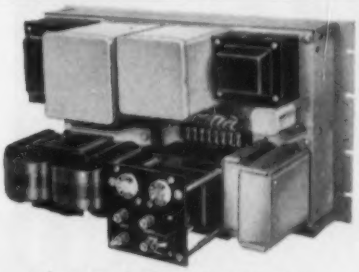
THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

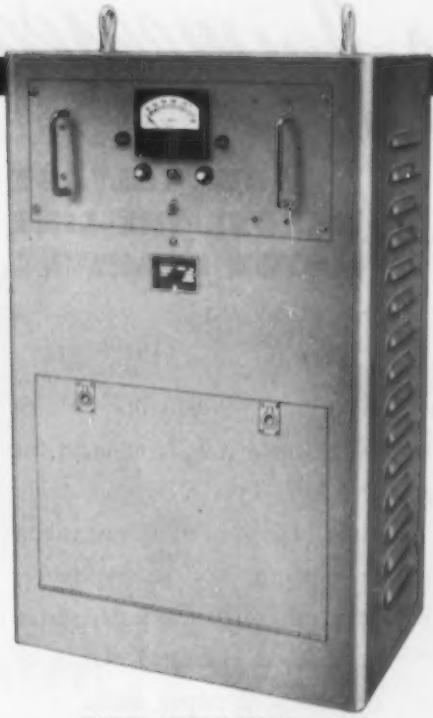
TT-1200



INSTANTANEOUS ELECTRONIC (type IE)
For instantaneous correction and extremely close control. Completely electronic. No moving parts.



TUBELESS MAGNETIC (type TM)
For unattended locations and critical uses where tube failure cannot be tolerated.



ELECTRO MECHANICAL (type EM)
For large industrial loads or for applications requiring zero waveform distortion and high efficiency.

STABILINE AUTOMATIC VOLTAGE REGULATORS

Designed to Maintain Root Mean Square Voltage

Here is a complete line of automatic voltage regulators designed with the application in mind . . . with *operating* characteristics that *always* equal or better the nameplate rating.

Of special importance is the fact that STABILINE maintains the root mean square voltage — the voltage rating for which all electrical equipment is designed. Before you purchase automatic voltage regulation equipment, make sure it is R.M.S. responsive.

We have detailed information about STABILINE automatic voltage regulators. Send the coupon for your copy of our Bulletin S351.

Be sure to see Superior Electric's Mobile Display when it is in your area.

THE SUPERIOR ELECTRIC COMPANY

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THE SUPERIOR ELECTRIC COMPANY
1309 Reynolds Avenue, Bristol, Conn.

Please send my copy of the STABILINE Bulletin

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For more data on advertised products, use Readers' Service Cards, last page.

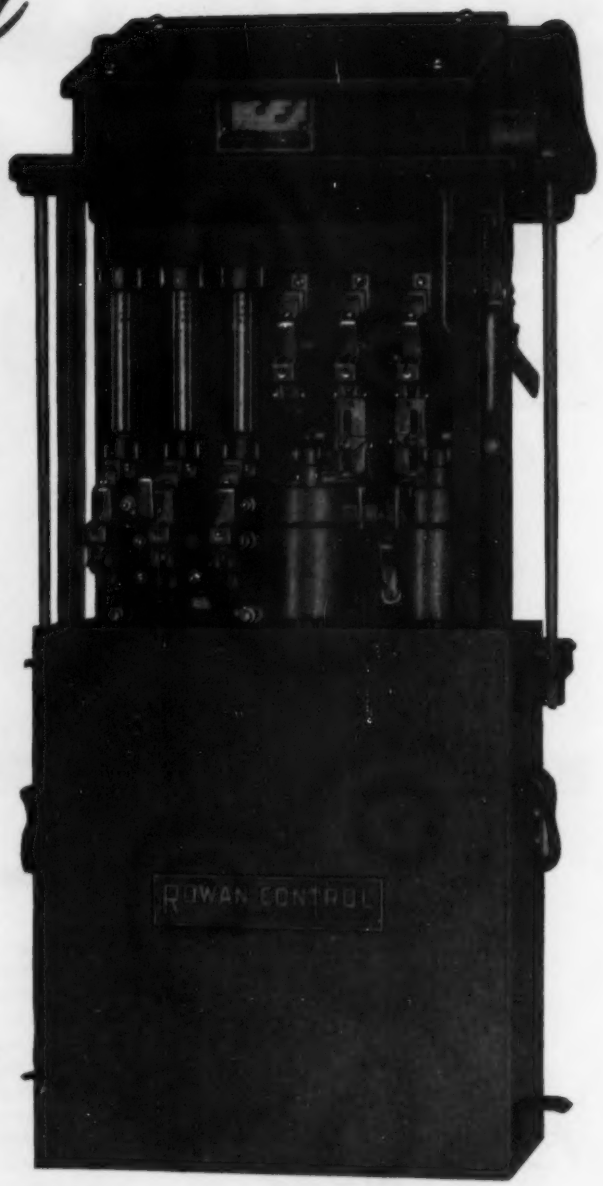
Oil Immersed

LOW VOLTAGE ACROSS-THE-LINE MOTOR STARTERS

Rowan Low Voltage, Across-the-line Motor Starters of the 780 Series are built to meet the requirements of NEMA Type XI and modifications are available for special applications. Their dependable performance under severe atmospheric conditions make them ideally suited for use in industries such as chemical plants, oil refineries, steel, cement and paper mills.

Incorporated in the 780 Series are such features as: easy access for inspection and maintenance; interchangeability of component parts with other starters of the same frame size.

Starters of the 780 Series are available in many combinations due to many variable components such as: safety disconnect switch, overload relays, Rowan AIR-SEAL fuses and wiring seal-off compartment.

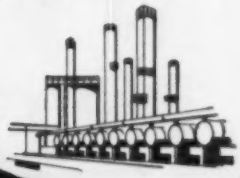


Type 780 KBF, Frame 50

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

insulation is a problem here . . . .

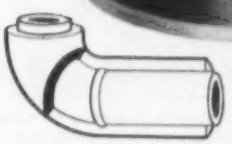


here's why

B&W SEAMLESS ALLOY WELDING FITTINGS ARE EASY TO INSULATE

Welding fittings can be insulated as easily as the pipe to which they are joined. The joints in welded construction are virtually flush, the weld metal forming a smooth continuous line with the pipe . . . application costs are minimized.

Maintenance costs are reduced . . . since soundly welded construction is leakproof, insulation need never be removed because of joint failure.



Insulation is applied easier and faster. Because sound welded construction is permanent and leakproof, there is no need to remove the insulation because of joint failure.

B&W SEAMLESS WELDING FITTINGS

GRADES:
Carbon, Alloy and Stainless Steel

TYPES:
Elbows, Tees, Caps, Saddles, Laterals, Nipples, Returns, Flanges, Stub Ends, Reducers, Crosses, Bull Plugs

SIZES:
Complete range of sizes and schedules

IT PAYS TO LOOK AT THE ADVANTAGES OF USING B&W SEAMLESS WELDING FITTINGS

Welded Construction Assures Minimum Pressure Loss — True circularity and radii, and smooth inner walls reduce friction and turbulence.

Whole Sections Can Be Shop-Fabricated — Ease of fabrication permits entire sections to be shop-fabricated and installed in a few minutes.

Welded Construction is Permanent — Maintenance costs are kept at a minimum because piping is permanently leakproof.

Welded Construction Takes Less Space — Piping can be nested in corners, or fitted against ceilings, walls or equipment.

Welded Construction is Simple to Install — Dimensional accuracy of angles, radii, and bevels, assures quick and easy joining.

Welded Construction is Lightweight — Strength combined with lightness in weight permits easy handling.

THE *NATURAL* SOURCE FOR ALLOY FITTINGS

B&W TUBULAR PRODUCTS DIVISION

THE BABCOCK & WILCOX COMPANY
Tubular Products Division • Fittings Department
3839 W. BURNHAM ST. • MILWAUKEE 46, WIS.

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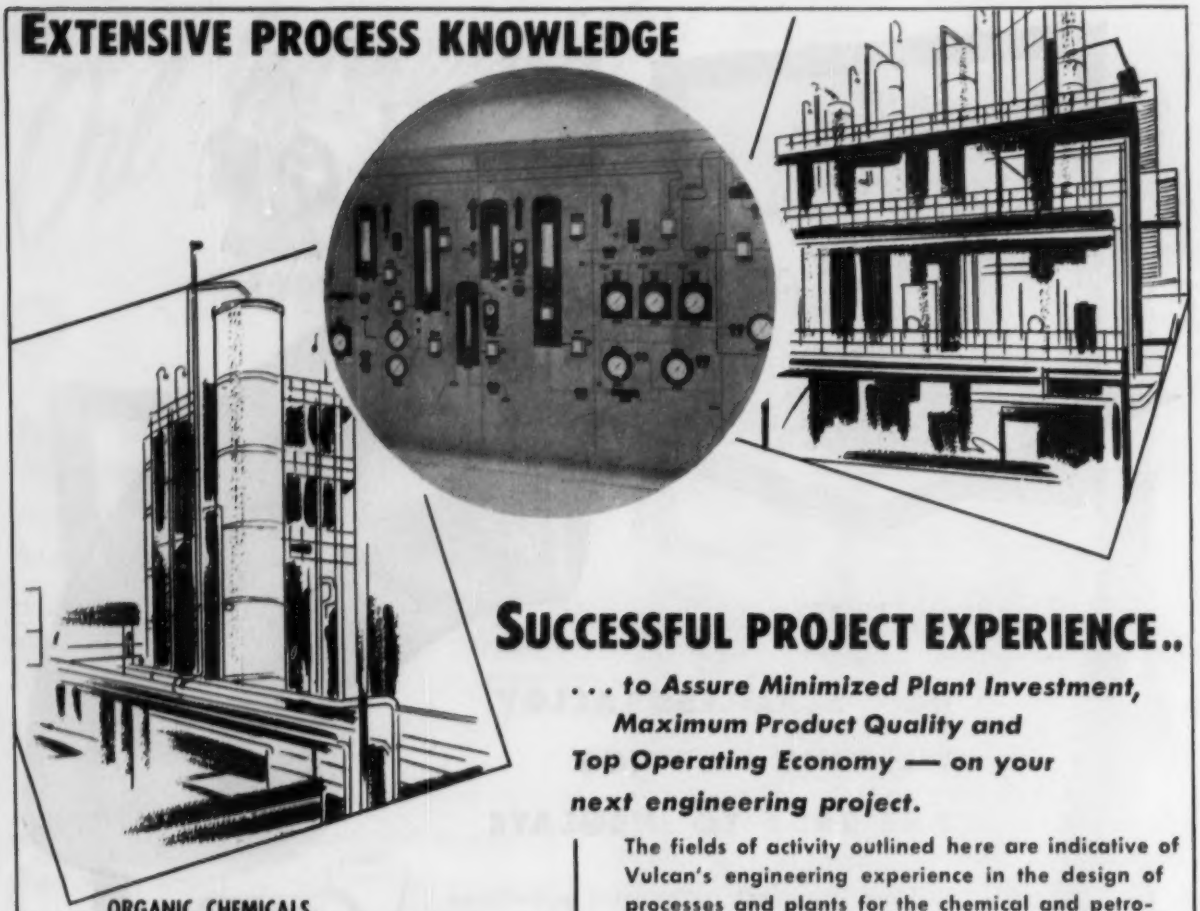
EXTENSIVE PROCESS KNOWLEDGE



SUCCESSFUL PROJECT EXPERIENCE..

. . . to Assure Minimized Plant Investment, Maximum Product Quality and Top Operating Economy — on your next engineering project.

The fields of activity outlined here are indicative of Vulcan's engineering experience in the design of processes and plants for the chemical and petrochemical industries. On each project, this experience is applied as an integrated body of knowledge and skills to the particular process requirements of the customer. It will pay to review your next project with Vulcan Engineering Division.

ORGANIC CHEMICALS

Synthesis, recovery, and purification of methanol, ethanol, propanols, butanols; formaldehyde, acetaldehyde, furfural; acetone, methyl-ethyl ketone; formic acid, acetic acid; esters, ethers, glycols, phenols and halogen derivatives of oxygenated organic compounds.

PETRO-CHEMICALS

Production and refining of ethylene, ethylene oxide, ethylene glycol, ethanol and other ethylene derivatives; isopropanol and methyl-ethyl ketone; butadiene, benzene, heptane, toluene, styrene, diphenyl; and chlorinated hydrocarbons such as chloroethane, chlorobenzenes and chlorotoluenes.

LOW TEMPERATURE GAS SEPARATION

Complete plants for separation of low and high purity oxygen from air; hydrocarbon separations; low temperature vessels for storage and transportation of gases.

WASTE DISPOSAL

Concentration and combustion of aqueous organic chemical waste liquors, particularly liquors containing carbohydrate and ligneous components; with provision for heat and power recovery where economically feasible.

CHEMICAL RECOVERY

Absorption, extraction and distillation processes for organic solvent recovery; sulfur dioxide recovery from sulfite pulp mill waste liquors and stack gases; organic vapor recovery from vent gases; recovery and refining of alcohols, aldehydes, acids and other chemicals from waste streams, fermentation and synthesis products and by-products.

EXTRACTION AND DIFFUSION OPERATIONS

Liquid-liquid and liquid-solid extraction processes for recovery and purification of liquid and solid organic chemicals; soluble coffee production; fiber washing and other specialized countercurrent diffusional operations.

FERTILIZER CHEMICALS

Ammonia, ammonium sulfate, ammonium nitrate, urea, urea ammonia solutions.

VULCAN ENGINEERING DIVISION

The VULCAN COPPER & SUPPLY CO., *General Offices and Plant*, CINCINNATI 2, OHIO

BOSTON CHARLOTTE, N. C. DENVER HOUSTON RICHMOND, VA. SAN FRANCISCO WILMINGTON, DEL.

VICKERS-VULCAN PROCESS ENGINEERING CO., LTD., MONTREAL, CANADA

DIVISIONS OF THE VULCAN COPPER & SUPPLY CO.:

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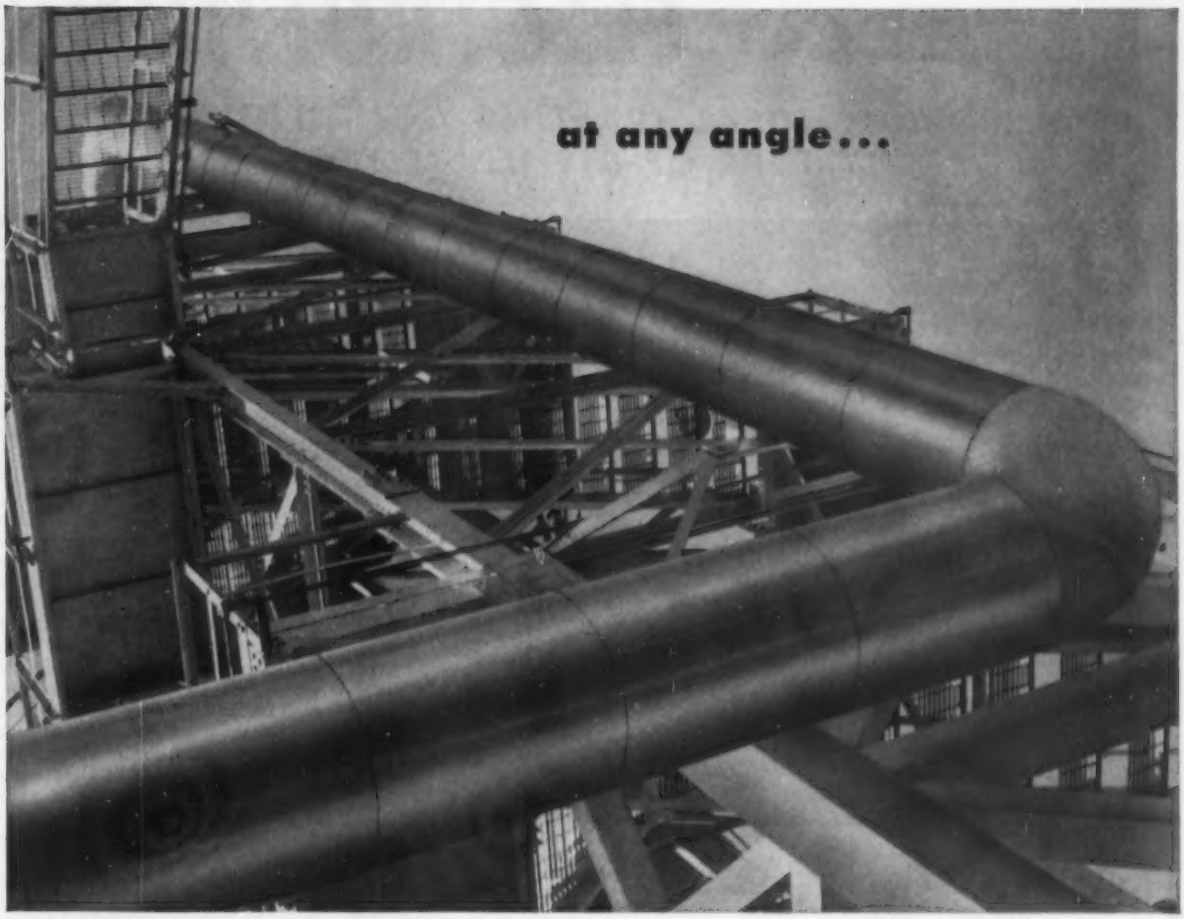
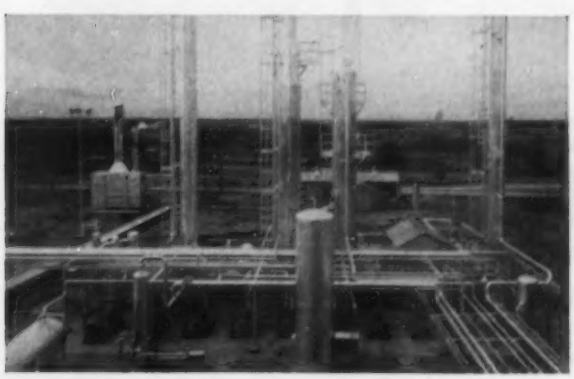


it's easier to insulate pipe with Unibestos®

NO MATTER HOW COMPLEX THE PIPELINE, Unibestos insulation makes installation simpler. It's easily cut, mitered, or grooved for effective insulation of bends, expansion joints, ells, tees and other fittings.

Unibestos' unique construction provides greater protection against heat loss—even at the difficult joints—than other nonfibrous insulation. Amosite, the African long-fiber asbestos, gives Unibestos the extra strength to resist shock and vibration. And Unibestos has excellent chemical stability...withstands moisture, steam, acid or chemical fumes.



STANDARD PRODUCTION SIZES

Unibestos Pipe Insulation is regularly made in 3-foot lengths for pipe sizes from ½" through 24", in standard thicknesses through 5". Unibestos Block Insulation is made in 6", 12", 18" or 36" widths and in thicknesses from 1" through 3" in ½" increments.

For complete information, write for descriptive Bulletin 109C

UNARCO®

UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street • Bloomington, Illinois

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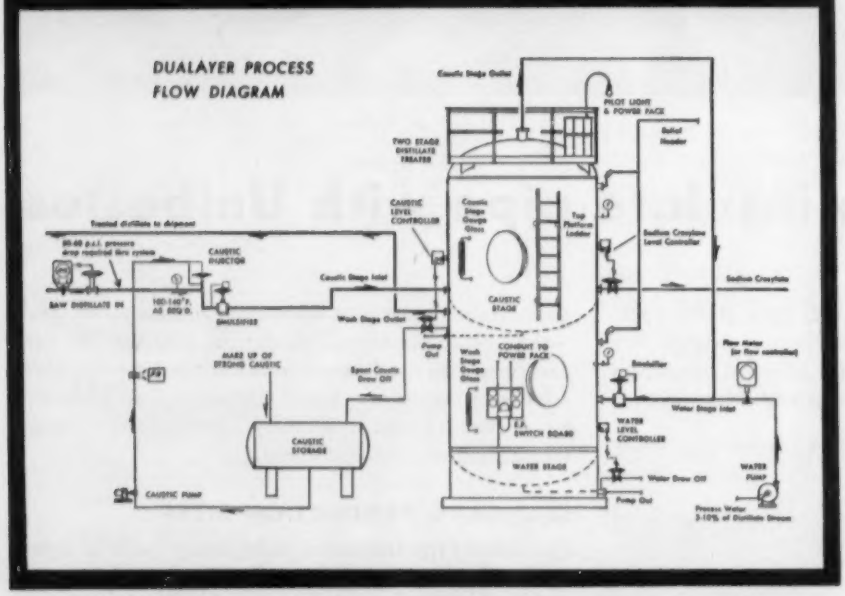
PETRECO ELECTROFINING

PROVIDES IDEAL TREATING CONDITIONS FOR ANY TYPE OF DISTILLATE TREATING



The photo and flow diagram at the left show Petreco Electrofining equipment utilized in the Distillate Fuel Oil Dualayer Process at the Magnolia Petroleum Company refinery at Beaumont, Texas.

In the Dualayer process, as designed by Magnolia engineers, distillate fuel oils are stabilized as to color and sediment formation. This is accomplished in Petreco equipment by contacting oils with a solution of concentrated sodium hydroxide or potassium-hydroxide. The salts of the organic acids, such as aromatic mercaptans, cresols and phenols, are insoluble in both the distillate and caustic. These liquid salts are withdrawn automatically from a layer intermediate between the distillate and caustic. The caustic is recycled for further distillate treatment. In the Electrofining vessels, treating losses are held to a fraction of 1%, consisting of only reaction products which are removed from the oil. After chemical treatment, the overhead distillate stream is water washed for removal of residual alkalinity. The wash water is removed from the distillate in a final stage of Petreco precipitation.

The two stage and three stage Petreco Electrofining equipment facilitates the operation of the Dualayer Process by providing an efficient means of precision-controlled, continuous mixing and separation. The Plant illustrated (left) has a treating capacity of 30,000 barrels per day of cat cracked distillate fuel.

Petreco Electrofining is applicable wherever it is desirable to contact a petroleum derivative with a treating chemical. It is currently in use for caustic scrubbing, acid contacting, doctor treating and Dualayer processing. In addition to the benefits that derive from inexpensive, reliable and efficient operation, the first costs of Petreco Electrofining equipment compare very favorably with that of conventional distillate treating systems.

For complete information, write or call

PETRECO®

A DIVISION OF PETROLITE CORPORATION

3202 South Wayside Drive, Houston 1, Texas • 1390 East Burnett Street, Long Beach 6, California

SPECIALIZED ELECTRIC PETROLEUM PROCESSING: DESALTING • DEHYDRATING • DESAPONIFICATION | DISTILLATE TREATING • SEDIMENT SEPARATION

97-11

See...

WHAT Vogt CAN DO FOR YOU..

Bulletin E-1 shows Vogt's advanced designs in heat exchangers, reactors, oil chillers, crystallizers, pressure vessels, steam generators and ice making and refrigerating machinery for countless applications in petroleum refineries, chemical plants, power plants and related industries.

Use the handy coupon below and send for your copy!

HENRY VOGT MACHINE CO.
Louisville 10, Ky.

Branch Offices: NEW YORK, CHICAGO, CLEVELAND, DALLAS, PHILADELPHIA, ST. LOUIS, CHARLESTON, W. VA.

Mail Coupon today

HENRY VOGT MACHINE CO.
10th & Ormsby Sts., Louisville 10, Ky.
Send copy of Bulletin E-1

NAME_____

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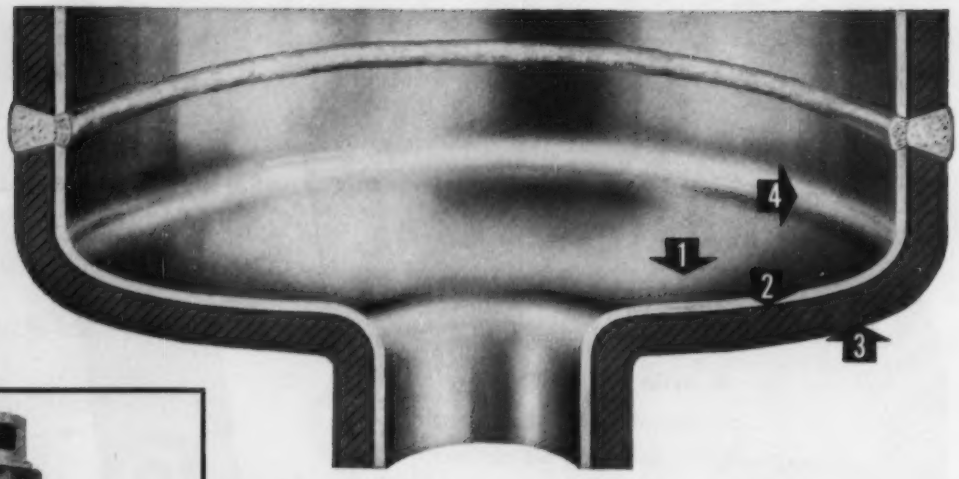
CITY_____ State_____

PR

For more data on advertised products, use Readers' Service Cards, last page.



This nickel-clad steel agitator kettle handles chlorinated hydrocarbons under severe operating conditions.

1. **ECONOMY**—High-alloy layer—usually 10% or 20% of total plate thickness—assures corrosion and abrasion resistance, long equipment life.
2. **DESIGN FREEDOM**—Integral bond allows design and fabrication of shapes to meet process and space needs.
3. **STRUCTURAL STABILITY**—Carbon or alloy steel backing gives required strength and rigidity at lower cost.
4. **LESS MAINTENANCE**—Smooth, hard surfaces, rounded corners and sloping bottoms mean easy cleaning and draining.

CLAD STEEL EQUIPMENT IS **EASIER** TO CLEAN AND MAINTAIN

In those parts of your process where unscheduled shutdowns mean a big operating loss, clad steel equipment's smoother, more uniform surfaces mean easier cleaning and drainage to help reduce over-all corrosion rates. Preventive maintenance is simplified, for clad tanks and vessels are easier to inspect than lined equipment. The layer of high-alloy cladding gives all the protection and corrosion resistance of solid alloy material, does not permit seepage or crevice corrosion.

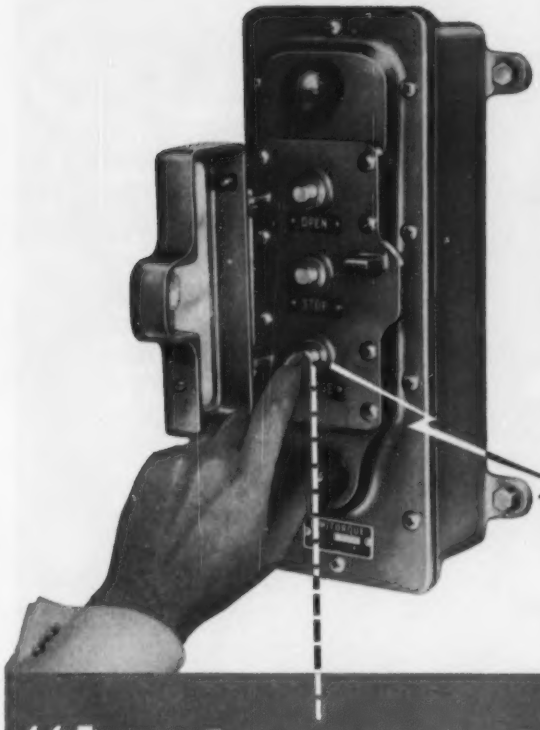
Sixteen types of Lukens' clad steel—stainless, nickel, Inconel, Monel, copper — give you these advantages at *savings up to 50%* in material costs over solid high alloys. The API-ASME Code permits full gage consideration for design purposes because cladding and backing are bonded over their entire surface.

Clad steel equipment assures long life with minimum maintenance, economy of field erection, resistance to thermal shock and easy modification as processes change. Take advantage of these benefits, check with *qualified* equipment builders. Working with your engineers and consultants, they can help you get more for your equipment dollar. We offer the widest selection of clad steels available anywhere and we can help in the selection of the type of clad steel that best suits your needs. If you would like more information, consult one of your equipment builders or write Manager, Marketing Service, 751 Lukens Building, Lukens Steel Co., Coatesville, Penna.

LUKENS CLAD STEELS

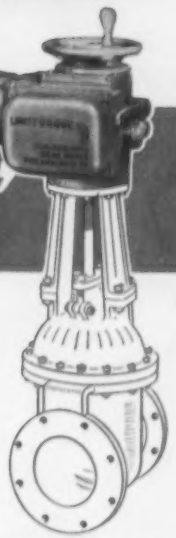
STAINLESS-CLAD · NICKEL-CLAD · INCONEL-CLAD · MONEL-CLAD

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEEL PLATES AND HEADS AVAILABLE



truly *Automatic* VALVE OPERATION *with* Limitorque®

"just press the button"



The above is a Type SMA-000 LimiTorque for operating smaller valves. There's a type and size of LimiTorque for every valve operating need.

Think of the time, labor and money that can be saved by opening and closing valves in remote, inaccessible or distant locations with LimiTorque . . . automatically, from a centrally located control panel. LimiTorque not only operates valves at the speed required, but it "limits the torque" applied to the valve operating parts and thus prevents damage to stems, seats, discs or gates . . . and too, the handwheel "cannot rotate" when the valve is being motor-operated. LimiTorque may be actuated by any available power source; such as electricity, gas, steam, water, oil or air—and is readily adapted for Microwave Control. Thousands of these units are being used in Power Plants, Oil Refineries and Pipe Lines, Water and Sewage Plants, Chemical Plants, Pulp and Paper Mills, and on Shipboard.

Send for Catalog L-54, and be convinced.

PHILADELPHIA GEAR WORKS INCORPORATED

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

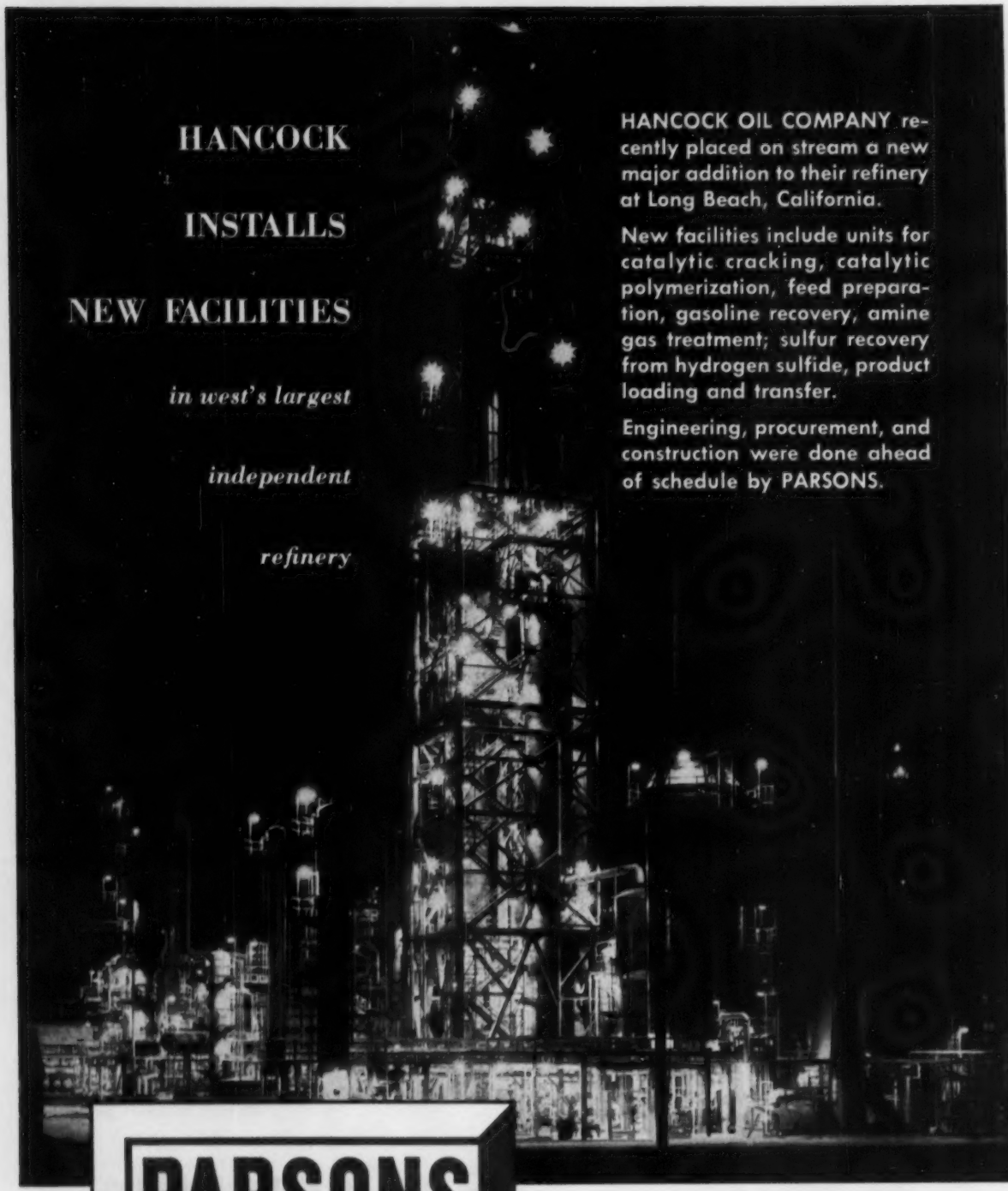
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA.
BALTIMORE • CLEVELAND

LimiTorque Corporation—Philadelphia

Industrial Gears & Speed Reducers • LimiTorque Valve Controls

ESTABLISHED 1892

For more data on advertised products, use Readers' Service Cards, last page.



HANCOCK

INSTALLS

NEW FACILITIES

in west's largest

independent

refinery

HANCOCK OIL COMPANY recently placed on stream a new major addition to their refinery at Long Beach, California.

New facilities include units for catalytic cracking, catalytic polymerization, feed preparation, gasoline recovery, amine gas treatment; sulfur recovery from hydrogen sulfide, product loading and transfer.

Engineering, procurement, and construction were done ahead of schedule by PARSONS.

PARSONS

THE RALPH M. PARSONS COMPANY

NEW YORK
TULSA
WASHINGTON

ENGINEERS · CONSTRUCTORS

617 South Olive Street, Los Angeles 14, California

ANKARA
BAGHDAD
BEIRUT
KARACHI
NEW DELHI
PARIS

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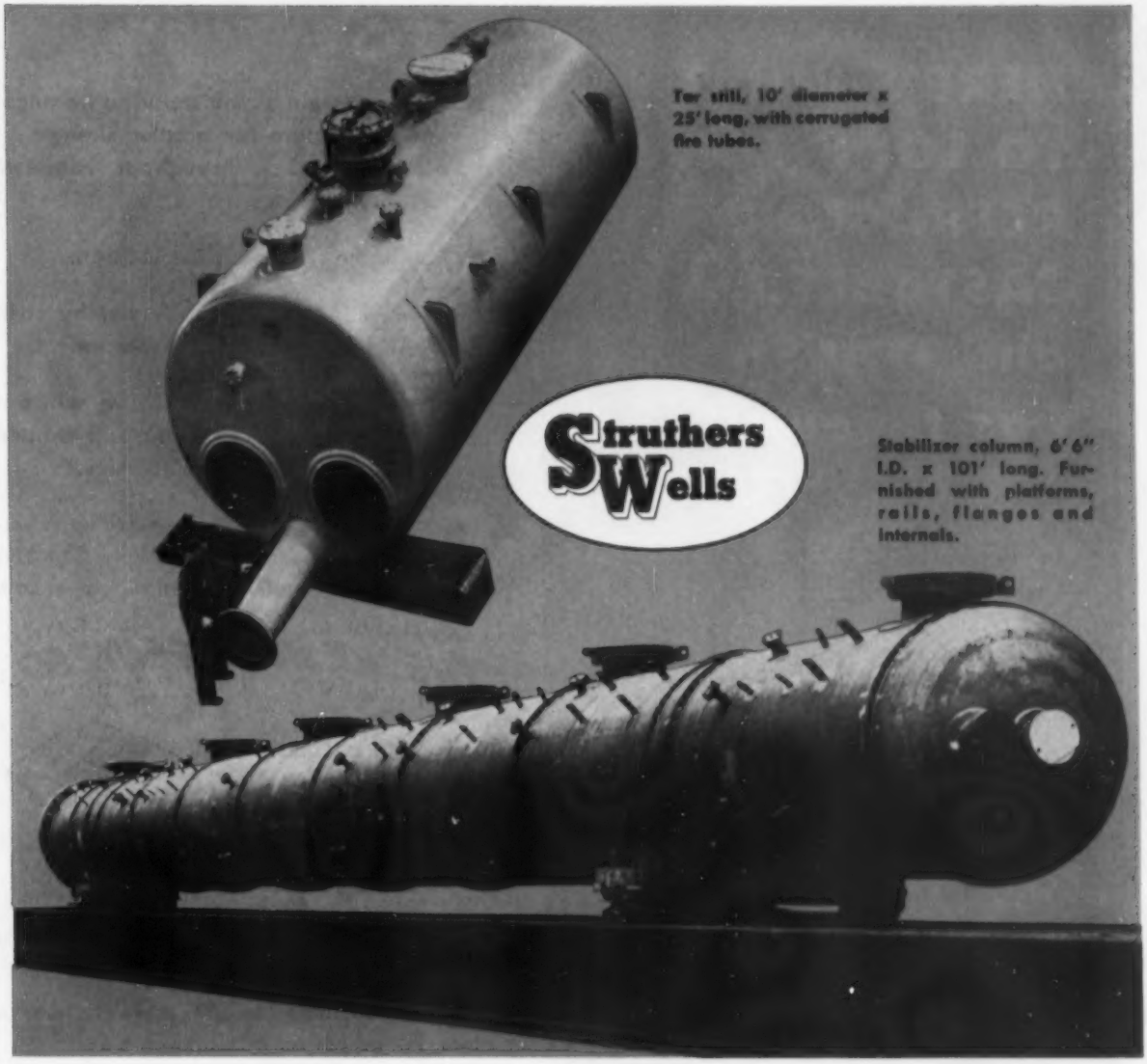

Tar still, 10' diameter x 25' long, with corrugated fire tubes.
Struthers Wells
Stabilizer column, 6'6" I.D. x 101' long. Furnished with platforms, rails, flanges and internals.

EQUIPMENT IS RIGHT FOR YOUR PROCESSING JOB

...when Designed and Fabricated by Struthers Wells

When you choose Struthers Wells as your process equipment fabricator, you place your requirements in the hands of highly skilled engineers, technicians, craftsmen and capable business men—whose aim is to provide you with highest quality equipment at lowest possible cost. All work is performed in our own plants—from production of forgings, weldments, patterns, etc., to machining, latest X-ray inspection, stress relieving and water quenching. Thus, you have undivided responsibility of control in the fabrication of equipment—in any metal or alloy—to meet all ASME or API Codes and your most exacting specifications. Backed by over 100 years of experience in the chemical and petroleum industries—you know equipment is *right* for your processing job when built by Struthers Wells.

Struthers Wells

STRUTHERS WELLS
CORPORATION
TITUSVILLE, PA.

Plants at Titusville and Warren, Pa.
Offices in principal cities

For more data on advertised products, use Readers' Service Cards, last page.

HERE'S WHAT TO LOOK FOR IN REFRACTORY CASTABLES... *and WALSH has them all...*

(thanks to better research and ceramic engineering)

Walsh Lite-Wate Castable No. 50 demonstrates remarkable trowelling workability

- **Uniform grain sizing assuring homogeneous structure for greater strength... better bond . . . throughout complete temperature range.**
- **Maximum resistance to abrasion.**
- **Ease of installation—whether by casting, trowelling or air gun placement.**
- **Highest modulus of rupture without sacrificing low "K" factor . . . wanted feature in light weight castables.**

These and many other advantages add up to performance characteristics that make Walsh Castables an investment in greater production... lower cost.

THEY'RE HOMOGENIZED

Lite-Wate Castable No. 50 . . . weight, dry, in place, 50 lbs. per cu. ft.

Lite-Wate Castable No. 70 . . . weight, dry, in place, 70 lbs. per cu. ft.

H & B Castable . . . weight, dry, in place, 130 lbs. per cu. ft.

Super Castable No. 32 . . . weight, dry, in place, 125-130 lbs. per cu. ft.

There's a light weight insulating or high temperature service type to meet your exact need. Get the whole time, labor and money-saving story from your nearest Walsh distributor or write us direct for complete data, temperature limits and prices.

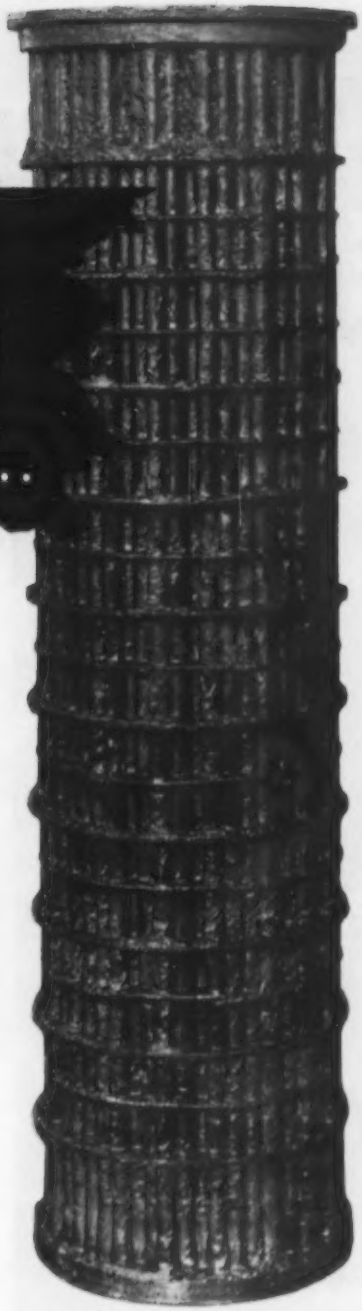
WALSH REFRACTORIES CORPORATION — America's Best Clays

WALSH REFRACTORIES CORPORATION

101 FERRY STREET • ST. LOUIS 7, MISSOURI

FOR OVER 60 YEARS MANUFACTURERS OF HIGH GRADE REFRACTORIES

don't let your
heat exchangers
get clogged
like this...



"IN-PLACE" chemical cleaning now quickest way to maintain bundle efficiency.

With Oakite chemical circulation method you can now clean heat exchangers in place. And here are a few of the many advantages awaiting you:

- **fast, thorough soil removal**
- **greatly reduced off-stream time**
- **elimination of costly manual methods**
- **greater safety and longer life for tube bundles**
- **plus the supervisory services of an experienced Oakite technician**
- **free drawings and control equipment**

For the complete story on heat exchanger cleaning by Oakite send for new 48-page Booklet "What Petroleum Men Should Know to Simplify Cleaning". Or write for the name of your local Oakite Technical Service Representative. No obligation. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

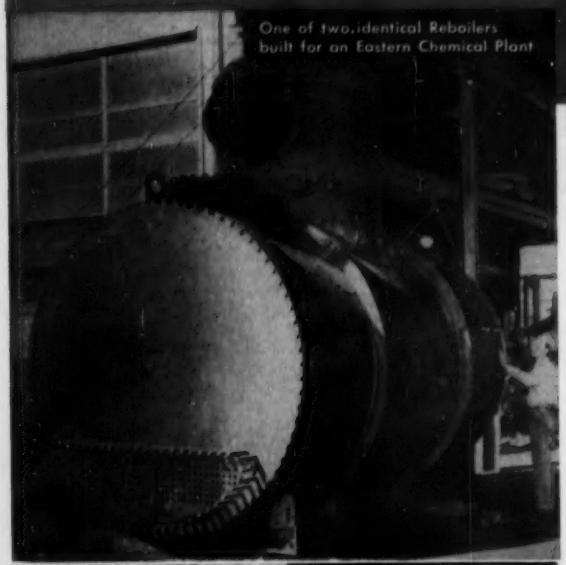
SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

Export Division Cable Address: Oakite

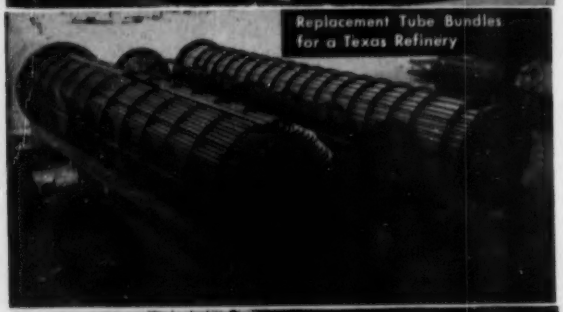
Technical Service Representatives in Principal Cities of U. S. and Canada

For more data on advertised products, use Readers' Service Cards, last page.

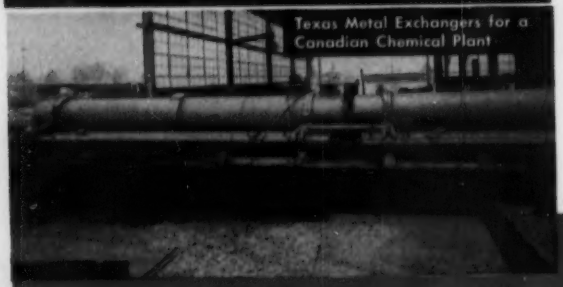
A Superior Service for HEAT EXCHANGERS



One of two identical Reboilers built for an Eastern Chemical Plant



Replacement Tube Bundles for a Texas Refinery



Texas Metal Exchangers for a Canadian Chemical Plant

The achievement of superiority in design and workmanship—unexcelled quality of construction—combined with competitive price and the lower maintenance factor of Texas Metal Exchangers is attested to by a long list of satisfied customers. It has been our privilege to serve many of the major companies in the petro-chemical industry.

We look forward to receiving inquiries and an opportunity to offer engineering counsel on any of your heat transfer problems.

Heat Exchangers • Condensers

Reboilers • Coolers

Preheaters

MTF

We cordially invite your inquiries.

API-ASME and ASME Code Construction

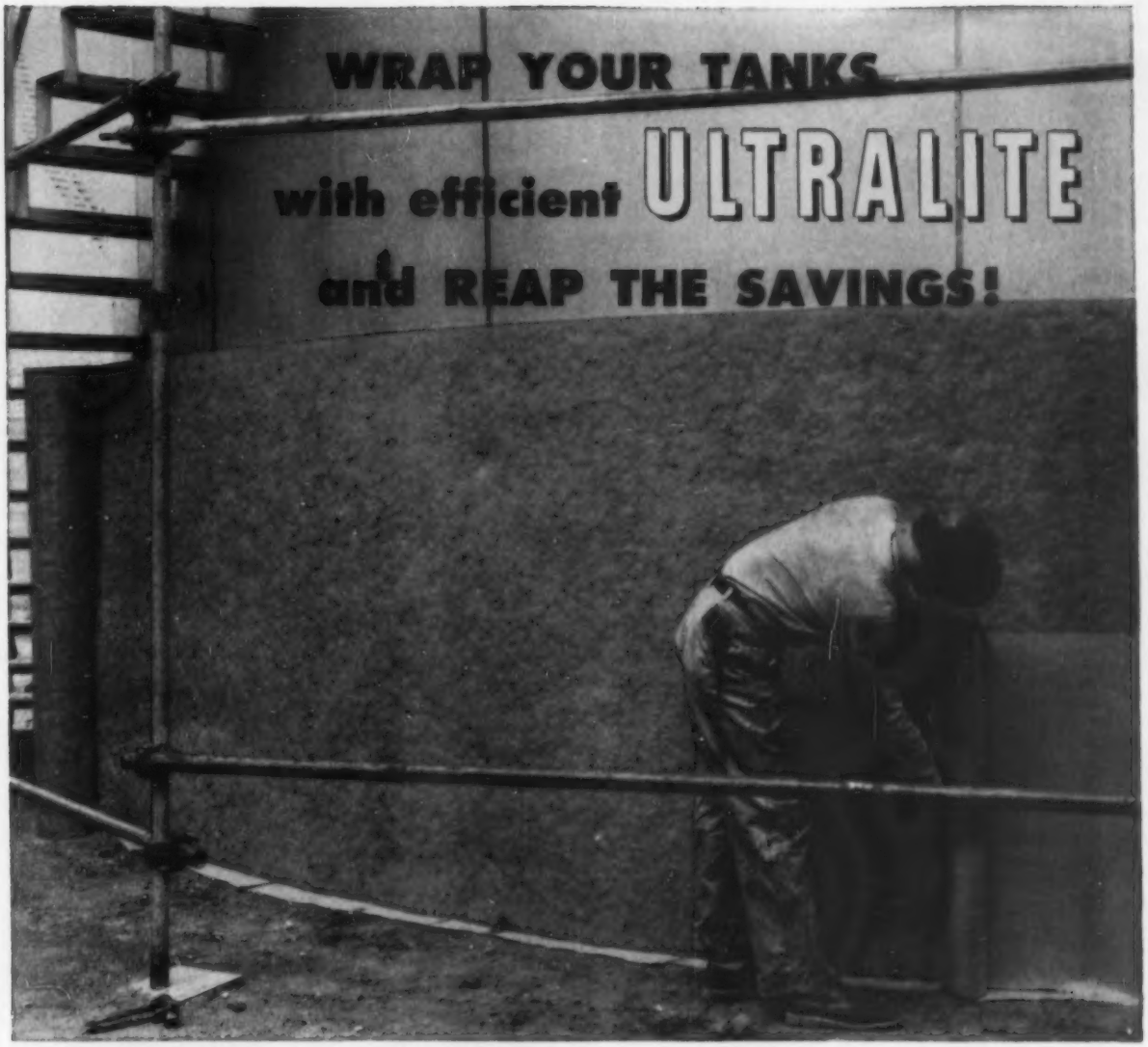
•

Qualified for Construction in Ferrous and Non-Ferrous Materials.

TEXAS METAL FABRICATING COMPANY

HOUSTON

MAIL ADDRESS: P. O. BOX 7567, HOUSTON 7, TEXAS



Quick as a flash, lightweight rolls of Ultralite glass fiber insulation can be run around tanks, vats and vessels — and that's more than *half* the battle in your war on insulating costs. The wider the roll, the quicker the job is done, and Ultralite is available in rolls up to *10 feet wide!*

Consider the advantages of this New Way vs. the Old Way on a tank of about 4,000 sq. ft., like the one pictured. To do the job with Ultralite required just 4½ rolls, 150′ long and in this case, 6′ wide. One man can easily carry such a roll. One man can easily apply Ultralite. But, if you were to use individual insulation bats, 24″ x 96″, you'd need 250 bats . . . and how many men would you say? And while you're figuring the saving, don't forget that you need twice as many welded mounting clips to apply bats as you do to apply Ultralite blankets.

Versatile and efficient Ultralite has other advantages, too, as insulation for all types of large heated equipment. It's resilient — not rigid — so that it can't crack under normal expansion and contraction. Its superior thermal efficiency means substantial heat savings over the years, and of course, Ultralite is as permanent as glass itself.

Next time, use Ultralite. It *figures.*

WRITE TODAY FOR "HOW-TO-DO-IT" DETAILS AND SPECIFICATIONS

GUSTIN-BACON *Manufacturing Company* GUSTIN gb BACON

Thermal and acoustical glass fiber insulations • Pipe coverings and fittings • Molded glass fiber pipe insulation

242 W. 10th St., Kansas City, Mo.

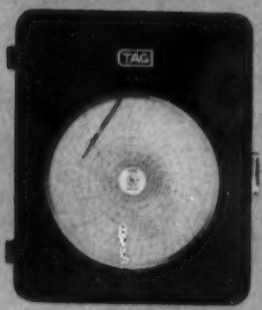
For more data on advertised products, use Readers' Service Cards, last page.

to regulate and record—

TEMPERATURE.. PRESSURE.. VACUUM..TIME

mechanical instruments by

WESTON



RECORDING INSTRUMENTS . . . in 9", 10" and 12" chart sizes — single and multipen — for all requirements.

RECORDING CONTROLLERS . . . handle temperatures from −325°F to 1000°F—vacuum to 30" mercury — pressures to 7500 psi or higher.

TIME CONTROLLERS . . . make any semiautomatic retort control system fully automatic. Available in both standard and special forms.

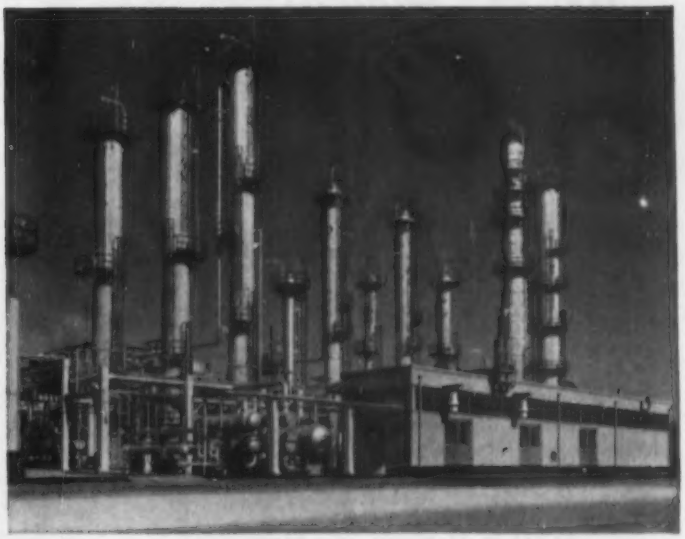
INDICATING CONTROLLERS . . . accurately regulate temperature, vacuum, pressure and indicate on direct-reading scale.

DIAL THERMOMETERS (remote reading) . . . furnished with mercury, gas, or vapor pressure actuations. Flush or wall mounting. Indicate low as −325°F., high as 1000°F.

Just Published!

Just published . . . the new catalog M2A which fully illustrates and describes the comprehensive line of WESTON mechanical instruments, noted for their long-time accuracy and dependability. Send for your copy today; or ask your local Weston representative for help on any measurement or control problem involving temperature, vacuum, pressure. Weston Electrical Instrument Corporation, 614 Frelinghuysen Ave., Newark 5, N. J., *a subsidiary of Daystrom Inc., 200 Elmora Ave., Elizabeth, N. J.*

WESTON *Instruments*



PARTNERS IN PETROCHEMICAL PROGRESS

It's a long road from the drafting board to the on-stream operation of a petrochemical plant, but it's a road which Procon has traveled successfully many times.

Outstanding among Procon's achievements in the petrochemical field are its installations of Udex extraction facilities for the production of high purity benzene, toluene, and xylenes. The quantity of these valuable aromatic hydrocarbons produced in Procon-built plants fills a substantial part of the industry's requirements.

As a construction organization, Procon will continue in its partnership with progress in petrochemicals . . . petroleum . . . and chemicals. It's a partnership for success.

PROCON *Incorporated*

1111 MT. PROSPECT ROAD, DES PLAINES, ILLINOIS

PROCON (CANADA) LIMITED—40 ADVANCE ROAD, TORONTO 16

PROCON (GREAT BRITAIN) LIMITED—112 STRAND, LONDON, W. C. 2

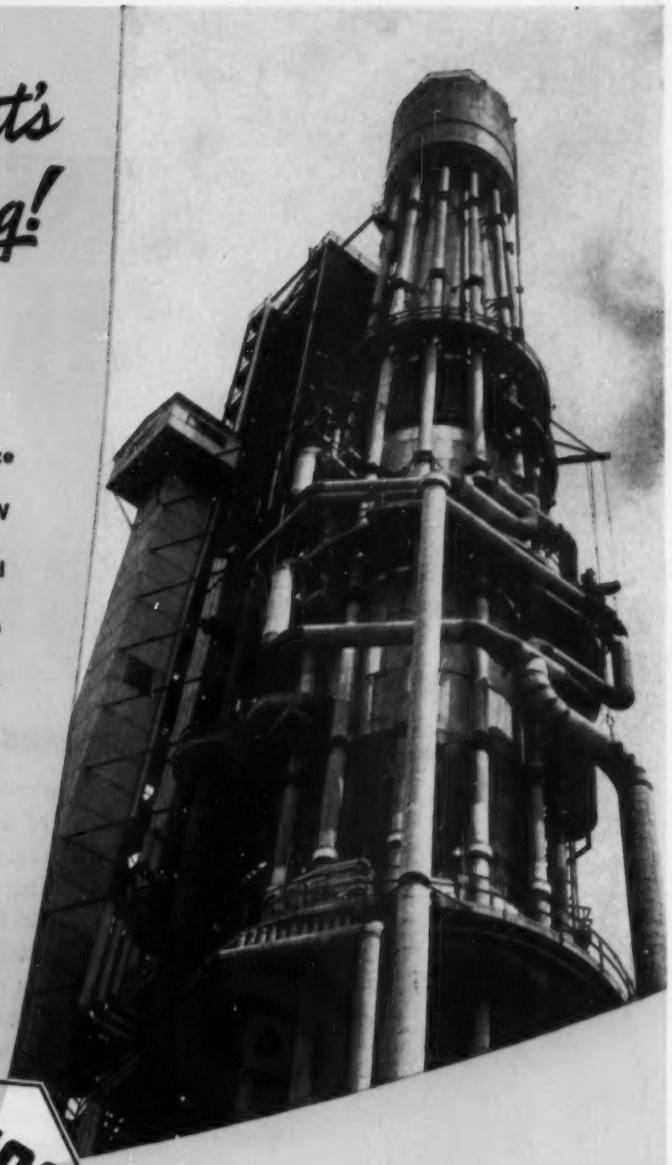
WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

For more data on advertised products, use Readers' Service Cards, last page.

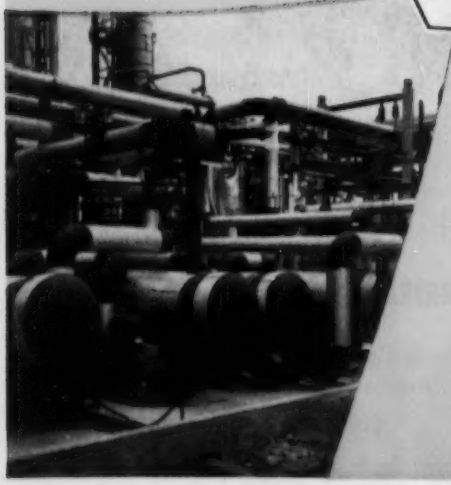
Well, now... that's very interesting!

but what is it?

By now, many refiners would recognize this giant as the new HOUDRIFLOW unit of the SUN OIL COMPANY located in Marcus Hook, Pa. Equivalent in height to 35 stories . . . 30,000 bbl./day capacity . . . this cat-cracker (only the upper half of which is shown here) was erected at a cost of approximately eight million dollars. It is the largest unit of its type in the world.



SUNOCO



And in the Quench Section and Vacuum Section this mighty "cat" chose Western Heat Exchangers constructed of alloy steel. Western backed its bid for this business with service that helped put the big HOUDRIFLOW on stream as scheduled.

WESTERN
HEAT EXCHANGERS
WESTERN SUPPLY COMPANY
P. O. BOX 1888 • TULSA, OKLAHOMA
HUDSON-RUSH COMPANY—753 Gladstone Blvd., Shreveport, La.
130 Casa Linda Plaza, Dallas 18, Texas
PROCESS INSTRUMENTS & EQUIP. CO. - North Bldg., Charleston, W. Va.
H. W. SEVERANCE—Marion E. Taylor Bldg., Louisville, Ky.

Highest Quality Chemicals for the Petroleum Industry

Solvay Chemicals have long set the standards for *dependable quality* in the petroleum industry!

Solvay Quality is the result of combining the world's finest alkali manufacturing facilities with the experience gained in the 74 years SOLVAY has been producing alkalies.

Fast, Efficient Delivery Service—SOLVAY'S nation-wide chain of great manufacturing centers and over 200 strategically-located supply points are in a better position to make prompt deliveries—especially during your peak production months.

Whether You're a Small or Large Refiner—you're always sure of receiving the *close, personal attention* that best fits your *individual needs!* Your specific *requirements* are handled by SOLVAY'S trained and experienced *local* field representatives operating out of SOLVAY'S 13 branch offices.

For Quality . . . Dependability . . . Service—make your first call SOLVAY by phoning or writing the SOLVAY office nearest your plant.

Soda Ash
Snowflake® Crystals
Potassium Carbonate
Calcium Chloride
Sodium Bicarbonate
Ammonium Bicarbonate
Cleaning Compounds
Caustic Potash
Sodium Nitrite
Ammonium Chloride
Chlorine
Caustic Soda
Monochlorobenzene
Para-dichlorobenzene
Ortho-dichlorobenzene
Chloroform
Methylene Chloride
Methyl Chloride
Carbon Tetrachloride

SOLVAY PROCESS DIVISION
ALLIED CHEMICAL & DYE CORPORATION
61 Broadway, New York 6, N. Y.

Allied Chemical

BRANCH SALES OFFICES:
Charlotte · Chicago · Cincinnati · Cleveland · Detroit · Houston
New Orleans · New York · Philadelphia · Pittsburgh · St. Louis · Syracuse

SOLVAY

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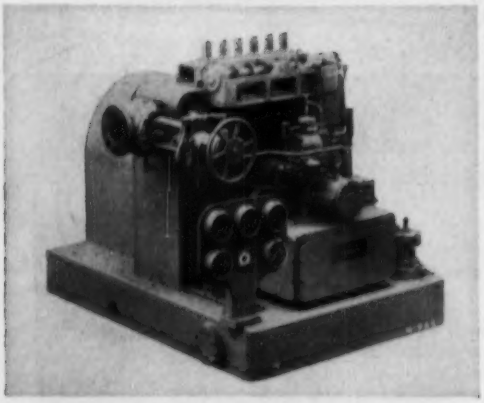
NIGHT VIEW of Cities Service Refinery, Lake Charles, La.

Worthington steam turbines keep refineries on stream



WORTHINGTON TYPE S MULTI-STAGE STEAM TURBINE provides drive for generators, pumps, compressors where dependability, close speed regulation, and economy are essential.

Dependable prime movers are a must where breakdowns can run into thousands of dollars a day. That's one reason Worthington steam turbines are the first choice for driving blowers and compressors throughout the petrochemical industry.

But that's only *one* reason for a Worthington steam turbine drive. Take our Type S multi-stage steam turbine. It also gives you:

1. **Close speed regulation** — almost any constant speed or droop characteristic desired. A fact worth noting: Worthington is the only manufacturer offering as standard equipment the Woodward direct-acting governor, Woodward Oil Relay governor, Constant or Variable Speed Oil Relay governor or a mechanical shaft governor to best suit your conditions of service and for maximum economy.
2. **Remote control.** The Woodward Governor with pneumatic or hydraulic head allows remote control using air or other medium.
3. **Steam economy.** Every Worthington multi-stage turbine is designed to fit your specific service with lowest steam consumption.
4. **Low upkeep.** Sound design, accessibility of parts, perfect lubrication, assure continuous service with minimum maintenance.

Find out more about the Worthington steam turbines for your chemical or petrochemical applications. Write Worthington Corporation, Steam Turbine Division, Section T.5.4, Wellsville, N.Y. T.5.4

WORTHINGTON

STEAM TURBINES

OIL FOR EUROPE'S INDUSTRY

The new deasphalting unit at Shell's Refinery at Pernis, near Rotterdam, The Netherlands, has a maximum design charge capacity of 12,000 barrels of reduced crude per day.

As part of an expansion program at their Refinery at Pernis, N.V. de Bataafsche Petroleum Maatschappij, a subsidiary of Royal Dutch Shell, employed E. B. Badger & Sons Limited, in collaboration with Stone & Webster Engineering Corporation, to design and engineer a new propane deasphalting and decarbonizing unit.

The unit produces lubricating oil base stock and catalytic cracking unit feed stock.

Important fuel savings are made by employing multiple effect evaporation for the first time in this type of unit to remove propane from the oil stream.

Design work was begun in September, 1952, and the unit – largest of its type outside of the United States – went on stream in the fall of 1954. Actual construction was by local contractors.

Write or call us for information as to how our experience may be of assistance to you.

STONE & WEBSTER ENGINEERING CORPORATION

BADGER PROCESS DIVISION

AFFILIATED WITH E. B. BADGER & SONS LIMITED (LONDON)

New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

stainless steel, too, means more than a shining face

A healthy youngster's natural grin is "chromium plated" after a conflict with soap and water. But it's his all-the-way-through character that measures his ability to cope with problems.

That's the way it is with stainless steel. And—important fact—varying amounts of chromium and other metals can be alloyed with steel to give stainless the specific all-the-way-through character needed to meet special problems.

Sun Ship has earned a reputation for mastering many special problems in its decades of service to the chemical, petrochemical, petroleum and other industries which face problems in fabrication and specialized machinery.

Now, with its new segregated Alloy Products Shop in operation, Sun Ship is using its experience and precise workmanship to adapt the superb qualities of stainless steel and other alloys to the equipment needs of the many industries it serves. In this shop are fabricated all grades of stainless, alloy, and aluminum.

Our Sales Engineering Department will be glad to discuss the value of this shop and its products in meeting your specific problems.

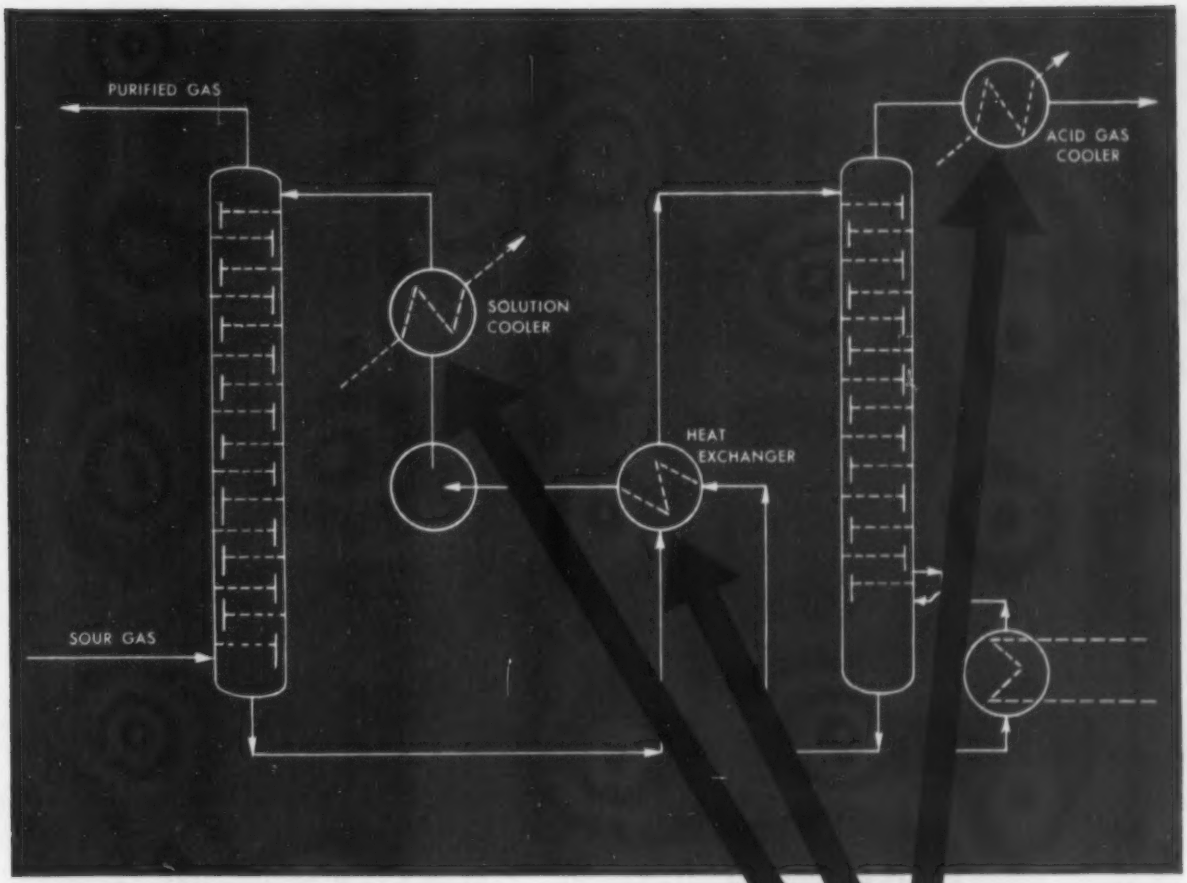
Sun Ship also makes all types of carbon steel pressure vessels.

ALLOY PRODUCTS SHOP

OF Sun SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • CHESTER, PA. • 25 BROADWAY, NEW YORK CITY

For more data on advertised products, use Readers' Service Cards, last page.



Carpenter Stainless Tubing

Cuts Refinery Corrosion Costs in Heaters and Coolers

This diagram shows where Carpenter Stainless Tubing has cut corrosion control costs and reduced down-time in refinery equipment used for removal and recovery of *hydrogen sulfide* from gases.

By re-tubing the solution heater and cooler and the acid gas cooler with Carpenter Stainless Tubing, tube life in these units already has been more than doubled. The Carpenter tubing has been in service more than 5 years and is still going strong. In other modern refinery processes, too, re-tubing with Carpenter Stainless Tubing is paying off in lower maintenance costs and increased plant operating efficiency.

Why not apply the cost-cutting, time-saving advantages of Carpenter Stainless Tubing to your operations to get greater freedom from costly corrosion troubles? Ask your local Carpenter Representative or write for information about the new kind of Carpenter Stainless Tubing now available for refinery services.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Here's a helpful guide for selecting standard and special analyses of stainless tubing and pipe for best results in corrosive services. Ask for Bulletin T. D. 113.

Carpenter

Stainless Tubing & Pipe

For more data on advertised products, use Readers' Service Cards, last page.

Three 20" Type DPL 600 lb. ASA Commercial Orifice Fittings check gas measurement on suction side of Compressor Station at Jackson, Miss.

...for CONTROLLED METERING *on oil and gas production, transmission and gathering lines*

SOUND DESIGN, sturdy construction and simplicity of operation mean longer life and lower operating costs for your orifice fittings. These features have made Commercial Orifice Fittings a preferred choice in the oil and gas industry since 1930.

There is a Commercial Orifice Fitting for every need and every type of service. Two chambered types with built-in plug valve permit changing the orifice disc while the line is under pressure. Deadline fittings are available with pin-locked covers for high-pressure service, while low-pressure fittings have stud-bolted covers; larger sizes are equipped with geared covers for safer operation.

For more detailed information, see your Composite or Refinery Catalog, or write

COMMERCIAL IRON WORKS

2424 Porter Street, Los Angeles 21, California

ARKANSAS, KANSAS, OKLAHOMA: The Condit Co., Tulsa 3, Okla.
CALIFORNIA: Fred P. Koenig Co., Long Beach 7
LOUISIANA: Coastal Engineering Corp., New Orleans 13
SOUTH and EAST TEXAS: Maintenance Engineering Corp., Houston 1
NORTH TEXAS: Vickery-Simms, Inc., Arlington
WEST TEXAS, NEW MEXICO: Beal Equipment Co., Odessa, Texas

There is a Commercial Fitting for every need

TYPE CN — Chambered, Bonnet Type
2" to 20"... 125 to 2500 lb. ASA

TYPE CS — Chambered, Swinging Type
24" and larger... 125 to 600 lb. ASA

TYPE DSB Deadline, Stud-Bolted Cover
2" to 24"... 125 to 600 lb. ASA

TYPE DPL — Deadline, Pin-Locked Cover
2" to 24"... 600 to 2500 lb. ASA

TYPE D-600 — Deadline, Stud-Bolted Cover
2" to 6"... up to 600 lb. ASA

MEXICO: Schultz y Cia., S.A., Mexico 5, D.F., Monterrey, N.L.
CANADA: Peacock Bros., Ltd., Montreal, Que.; Toronto, Ont.; Calgary and Edmonton, Alta.; Vancouver, B. C.

OUR FIFTIETH YEAR SERVING THE OIL AND GAS INDUSTRY

GOING PLACES *down on the farm with Cities Service...*

The mechanized farm equipment, vehicles, and heating units that make life easier for America's farm families... all depend heavily on Cities Service quality petroleum products.

CITIES SERVICE
A Growth Company

Number 12 of a series

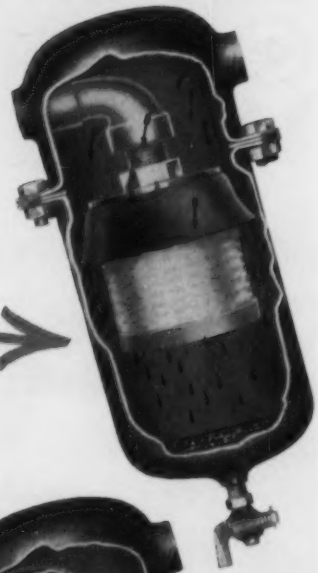
For more data on advertised products, use Readers' Service Cards, last page.

STAYNEW FILTERS' DOUBLE ACTION

Guards Against Water, Oil and Pipe Scale

MECHANICAL SEPARATION

1. Deflector cup directs flow of air or gas together with water, oil and dirt to the walls of the housing and then downward at high velocity into the base where liquid and heavier dirt particles are deposited.



FILTRATION

2. Air or gas, having been mechanically cleaned, rises at low velocity through the Radial Finned Filtering element or insert which removes the lighter air-borne material.

MODEL CPH
PIPE LINE FILTER

This exclusive Double-Action principle of Staynew Pipe Line Filters assures sustained, trouble-free operation. Inexpensive, quickly installed and easily maintained, these filters keep air operated or controlled equipment free from pipe scale, dust, dirt, and condensate. Wherever you require air and other gases *clean* and *dry*—demand and get—Staynew Pipe Line Filters.

Write today for complete Staynew Pipe Line Filter Bulletin B-1A.

Representatives in Principal Cities

DOLLINGER PROTECTO MOTOR STAYNEW FILTERS

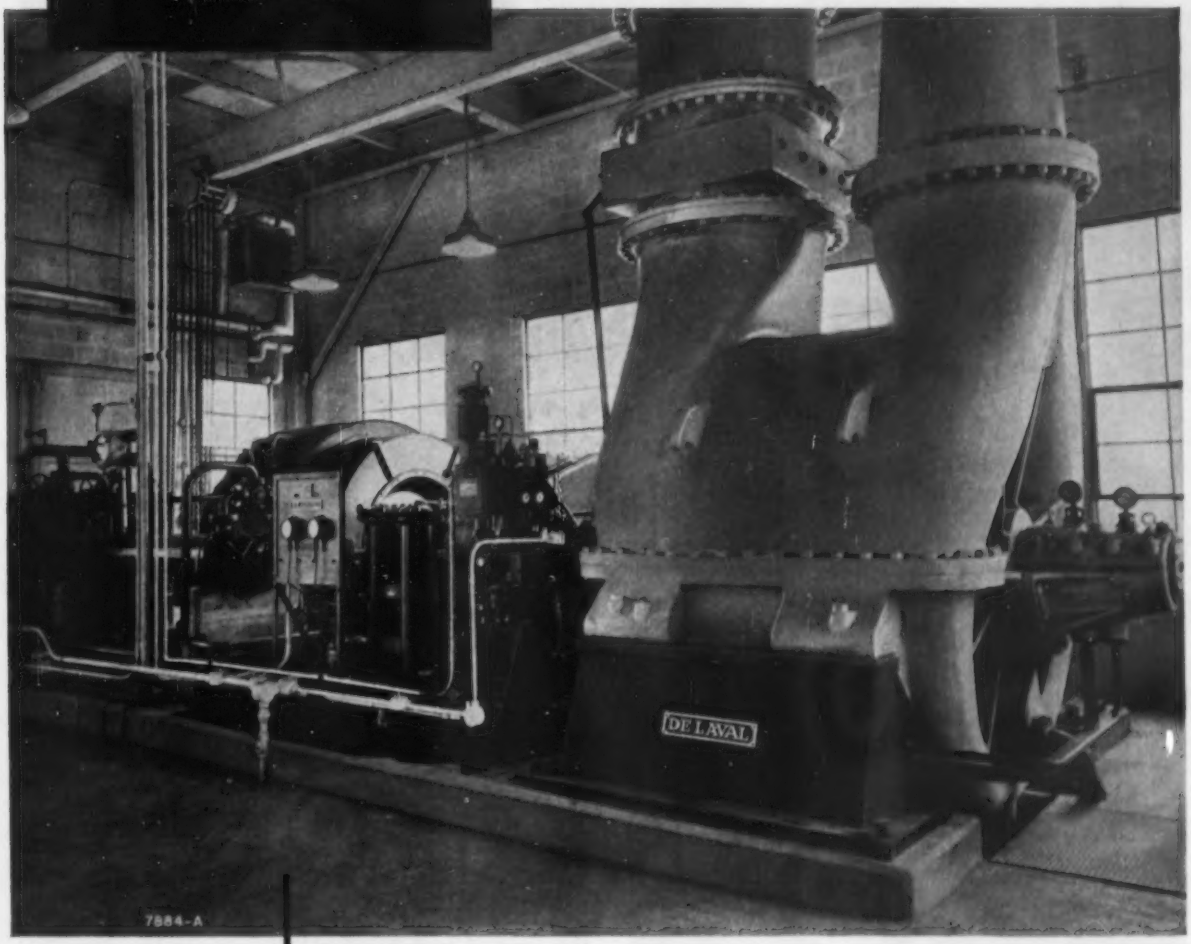
DOLLINGER CORPORATION

47 Centre Pk., Rochester 3, N. Y.

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

DE LAVAL
CENTRIFUGAL
BLOWER

supplies 48,400 cfm for new British American cat cracker



Send for new Bulletin 0504

This De Laval centrifugal blower does a dependable job in the new Model B Orthoflow cat cracker of the British American Oil Co., Ltd. at Clarkson, Ontario.

The unit delivers 48,400 cubic feet of air per minute for the regeneration of spent catalyst. Inlet pressure is 14.2 psia, and discharge pressure 35.4 psia. The De Laval blower operating at 3,700 rpm is driven through a speed increasing gear by a 4,500 hp electric motor.

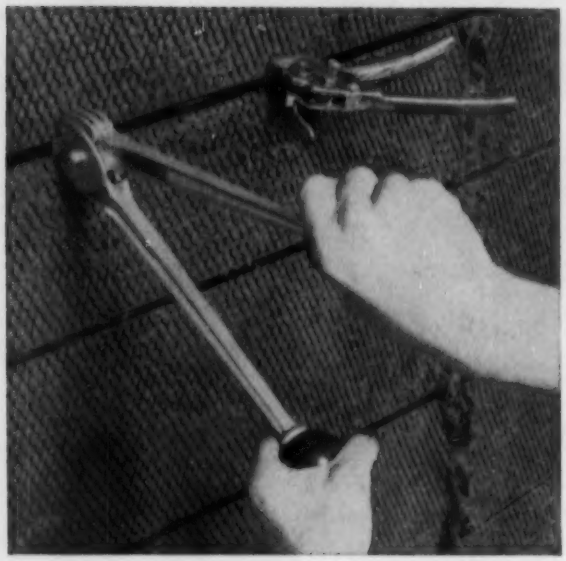
De Laval blowers are designed and built for heavy duty continuous operation. Rugged, horizontally split casings, individually designed impellers, perfectly balanced rotors and externally mounted, cylindrically seated bearings are design features that assure optimum performance and long service.

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL507

EAGLE-PICHER
BLANKET INSULATION
FACTORY FABRICATED to rigid specifications



FACTORY FABRICATION is your assurance Eagle-Picher Blankets are completely free of large "voids" usually found in field made blankets where insulation is simply packed in place. Because they're uniform these blankets can be tightly butted together to eliminate cracks and loose joints.

FACTORY FABRICATED to rigid specifications is your assurance that copper bearing steel laths, bound by uniformly spaced soft-drawn galvanized tie wires, keep the blankets firm but flexible. They can be quickly applied to flat or slightly curved surfaces on any large heated equipment—or cut to fit irregular areas.

FACTORY FABRICATED to rigid specifications means that *every* blanket is made up of many layers of Eagle-Picher mineral wool uniformly dispersed over the entire area of each blanket. The outstanding chemical and physical characteristics of Eagle-Picher mineral wool provide maximum thermal efficiency at temperatures as high as 1200 F.

WRITE FOR FREE SAMPLE TODAY!

Prove to yourself that Eagle-Picher Blankets are factory fabricated to meet your own exacting standards!

Since 1843

EAGLE EP PICHER

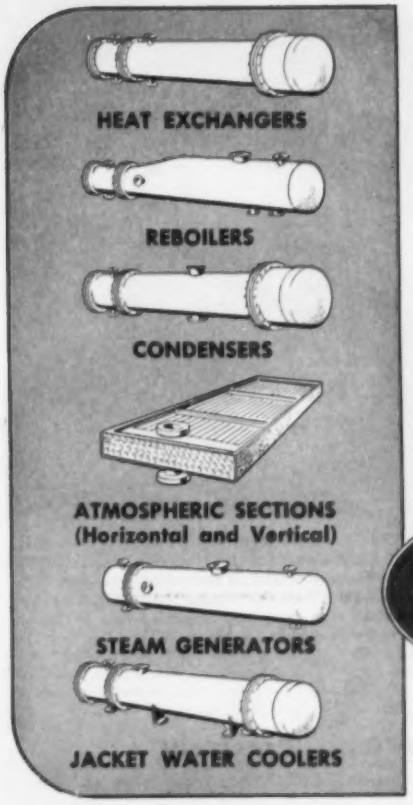
THE EAGLE-PICHER COMPANY

Producing a complete line of industrial insulations

Cincinnati 1, Ohio

(Member of Industrial Mineral Fiber Institute)

(Conforms to Commercial Standard CS 117 and Federal Specification HH-I-563)



● If your problem is the poor performance or high maintenance cost of your heat transfer units, consult an EFCO engineer. He will help you decide the changes or modifications necessary to get the desired performance from your heat transfer equipment.

Backed by knowledge and experience, EFCO engineers are constantly working to produce heat transfer units that will give efficient performance and long, trouble-free operation.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

EFCO HEAT TRANSFER EQUIPMENT

For more data on advertised products, use Readers' Service Cards, last page.

Which of these two instruments provides the temperature control accuracy you need?

1. **IT'S ELECTRONIC!** The new Series 560 applies the thermistor principle in temperature indicator controls with heretofore unattainable accuracy over a scale range of 200° to 600°F. It's the *only* instrument that provides the three major control modes — (1) on-off (2) proportional (3) adjustable differential — all at the flip of a switch. Wide range of use for general laboratory, processing, molding or packaging applications.

2. **IT'S MECHANICAL!** The new Series 540 indicating controller combines low cost with high accuracy over a temperature range of 100° to 700°F. Temperature changes are transmitted by a bulb and bellows to an indicator control. Instrument features on-off control . . . adjustable differential . . . ambient compensation. May be flush or surface mounted. Capacity of 15 amps at 115 volts.

3. **SIMPLICITY ITSELF** is secret of Fenwal's Series 560 — accuracy, sensitivity and ruggedness. The thermistor's high resistance change permits operation with any length of lead wire up to 200 feet without affecting signal strength or accuracy. Thermistor is hermetically sealed in glass for stability; encased in stainless steel for ruggedness. No complex circuitry; maintenance is easy.

4. **EASY "SET" AND "CHECK" OPERATION** is a feature of Fenwal's Series 540 which is accurate to within 2% over the 100° to 700°F range, including the effects of ambient temperatures. Send for FREE NEW BULLETINS, MC122 on the Series 540, MC123 on the Series 560. Both contain full data you should have. Write to **Fenwal Incorporated, 109 Pleasant St., Ashland, Mass.**

Fenwal Controls Temperature... *Precisely*

For more data on advertised products, use Readers' Service Cards, last page.

WEED PROBLEMS?

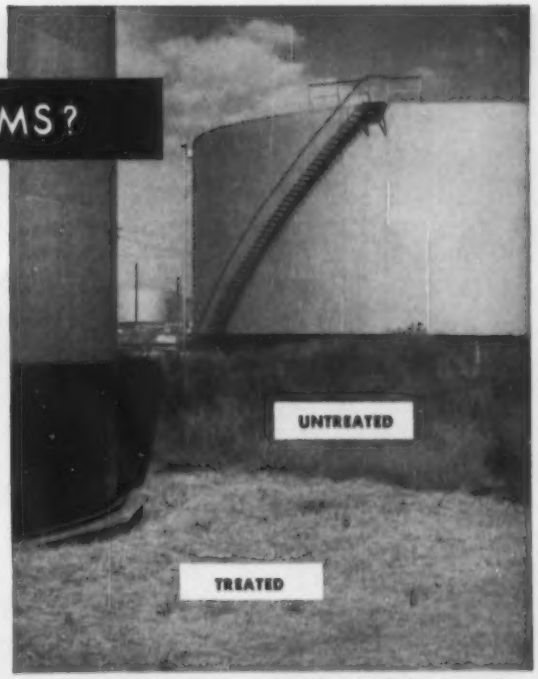
One application of

Du Pont Telvar®

WEED KILLERS

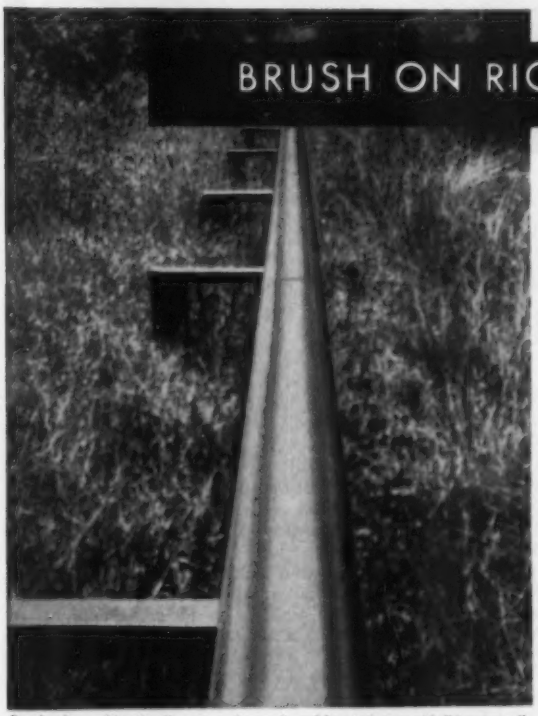
stops weeds for the season—or longer!

"Telvar" kills weeds through the roots . . . prevents regrowth. Low rates (20 to 80 lbs. per acre) make it cost little for the results you obtain . . . also mean less handling, fewer storage problems. To cut maintenance costs to new low levels, put "Telvar" in your weed-control program. Available in two formulations: "Telvar" W, and "Telvar" DW.



"Telvar" is ideal for weed control around tank farms, pipelines, pumps and derricks. It's non-toxic to humans and animals, non-flammable, non-volatile and non-corrosive to equipment.

BRUSH ON RIGHT-OF-WAY?



Brush along this pipeline was cleared and kept down with "Ammate." "Ammate" allows low-growing cover to return to resist erosion.

One application of

Du Pont Ammate®

WEED AND BRUSH KILLER

kills more kinds of brush —safely—at lower cost!

"Ammate" kills more kinds of brush and keeps it down longer than most weed and brush killers! When the original spray job is done well, brush is kept under control for years with only an occasional spot spray. You can rely on "Ammate" to do the job safely, even where your right-of-way adjoins cropland, because "Ammate" is not volatile. There are no vapors to drift onto sensitive crops. It is no hazard to crews, stock or wildlife.

FREE ILLUSTRATED BOOKLETS describe how to control weeds and brush with Du Pont chemicals. For your copies, write to Du Pont, Grasselli Chemicals Dept., Rm. D-4032, Wilmington, Del. In Canada, Du Pont Company of Canada Limited, Box 660, Montreal.

On all chemicals always follow directions for application. Where warning or caution statements on use of product are given, read them carefully.

Telvar® [Weed Killers for industrial use

DU PONT REG. U. S. PAT. OFF.

Ammate® Weed and Brush Killer

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTR

For more data on advertised products, use Readers' Service Cards, last page.

Maltese Cross Fire Hose for severest service . . . extra strong yet light and flexible. Standard lengths: 50 feet—tested up to 400 psi.

MALTESE CROSS® FIRE HOSE

IS THE FINEST IN FIRE PROTECTION

Maltese Cross Fire Hose has *never* failed at a fire, has always given peak performance when needed as shown in these three case histories.

(1) . . . A large New Jersey refinery battled a stubborn fire with five brands of fire hose. All brands burst on the job except Maltese Cross Fire Hose, and that same hose has been in use now for over 30 years!

(2) . . . Not one length of 20-year-old Maltese Cross Fire Hose failed in one of the century's worst refinery fires. Thirty-nine lengths of other brands of fire hose burst during action.

(3) . . . A large refinery refused to buy higher priced Maltese Cross Fire Hose but settled for a lower cost hose. When a fire occurred their cheaper hose lengths burst one after another. They borrowed hose from a nearby refinery . . . Maltese Cross Fire Hose. Not one length burst. Today Maltese Cross Fire Hose is a standard part of their fire-fighting equipment.

Here is proof that Hewitt-Robins Maltese Cross Fire Hose offers the greatest safety and economy over the years . . . it will never mildew or dry-rot during storage . . . it is oil, acid and abrasion-resistant and built to withstand the severest pressures . . . it's the *handmade* fire hose whose wrapped construction includes four tough flexible plies of specially woven duck combined with premium rubber compounds. Maltese Cross Fire Hose is widely used and approved for oil tanker service because it resists weathering and salt spray.

Your investment in Hewitt-Robins Maltese Cross Fire Hose will insure *complete* and *proven* protection in your industrial fire protection system.

Hewitt-Robins

Industrial Hose—Conveyor Belting—Conveyor Machinery—Vibrating Screens—Vibrating Conveyors—Design, Manufacture, Engineering and Erection of Complete Bulk Materials Handling Systems.

HEWITT-ROBINS INCORPORATED • STAMFORD, CONNECTICUT

The most compact, reliable sampler ever built . . .

THE NEW Gilbarco

Small in size...
light in weight

AUTOMATIC SAMPLER

Here's a new compact, completely automatic, magnetically powered and electronically controlled sampler designed to provide a continuous sample from process or pipe lines.

USERS GET ALL THESE IMPORTANT ADVANTAGES.

- ★ Proportional to time or flow
- ★ Settings for 20 to 300 cycles per minute for more accurate sampling
- ★ No packing glands, no leakage
- ★ No electric motor, no mechanical switches
- ★ Simple to install and service
- ★ LOW initial cost . . . LOW maintenance cost
- ★ Completely explosion-proof . . . no pressure relief valves required
- ★ No hold-up time from pipe line to sample receiver; because a portion of the stream is by-passed through the sampler

Before you buy any other sampling unit, write for full details on this New Automatic Sampler.

GILBERT & BARKER MFG. CO. • WEST SPRINGFIELD, MASS. • TORONTO, CANADA

For more data on advertised products, use Readers' Service Cards, last page.

Brown Fintube

The above photo shows a large Houston Petro-Chemical (Synthetic Ammonia) Plant with 9 compressor stations . . . a total of 54 coolers or 306 high pressure heat exchanger sections. Pressures from 72 psi to 5300 psi.

Brown high pressure heat exchanger sections are now performing, with high efficiency, in almost all the Petro-Chemical plants that have been built in the last five years.

BFT high pressure sectional heat exchangers are available for pressures up to 22,000 psi.

High Pressure

HEAT EXCHANGER SECTIONS

HEAT EXCHANGE SURFACE
BROWN FINTUBE
HEAT TRANSFER PRODUCTS

BROWN FINTUBE COMPANY

Elyria, Ohio

BOTH EYES OPEN

There are darn few supply stores in the jungles of Brazil or the rugged hills of Portugal. And that's one of the reasons why plant executives with an eye on foreign operations choose BORN "UPFLO" HEATERS. Repairs, maintenance, or shut-downs in these remote areas are costly, so a heater which can deliver year after year of trouble-free operation will result in tremendous savings.

But there's *another* side to the story of Born's popularity, too. In North America, Born heaters are saving millions of dollars every year, even though they may be right next door to a supply house! That's because BORN "UPFLO" HEATERS are *more efficient;* save on fuel costs every day they're in operation.

At this moment, BORN "UPFLO" HEATERS have been furnished for service in India, the Philippines, Formosa, Brazil, Venezuela, Colombia, Italy, Japan, and Portugal — in addition to the hundreds of Born heaters all over the United States and Canada. Over 1,000,000 barrels of Petroleum Oils and Distillates *per day* are being economically processed by these efficient, rugged units.

Just where the next "UPFLO" heater will crop up, nobody knows. But you can bet your best "Stetson", it will be ordered by an executive who does his buying with *both eyes open!*

BORN *Engineering Company*

ENGINEERS and CONTRACTORS

TULSA, OKLAHOMA

BRANCH OFFICES:
Denver, Colo.; Houston, Tex.; Los Angeles, Calif.; New York, N. Y.; Shreveport, La.

FOREIGN OFFICES:
Canadian Brown Steel Tank Co., Ltd.
Brandon, Manitoba, Canada
Grander & Cia. S. A.
Tacuari 210
Buenos Aires, Argentina
Premafrance
36 Boulevard Gouvion St. Cyr
Paris 17, France

For more data on advertised products, use Readers' Service Cards, last page.

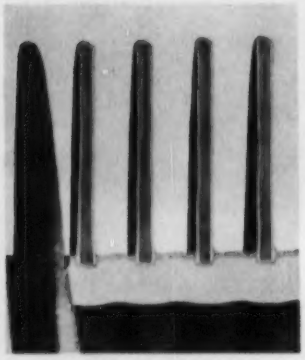


Photo-macrograph of the G-R High-Temperature K-Fin, showing the dual-metal helical fin sealed to the tube by a special brazing alloy. The construction is fully explained in bulletin which will be sent on request.

You can recover heat from gases at extreme temperatures

The G-R High-Temperature K-Fin Heat Transfer Surface now enables you to put to useful work the extremely hot waste gases produced by combustion, by catalytic reactions, or by regeneration of catalysts.

This special G-R finned tube construction can be applied to furnaces or convection heaters with inlet gas temperatures as high as 2600 F, heating fluids such as molten metals to temperatures up to 1500 F.

Write for full information on design and applications. GR 250

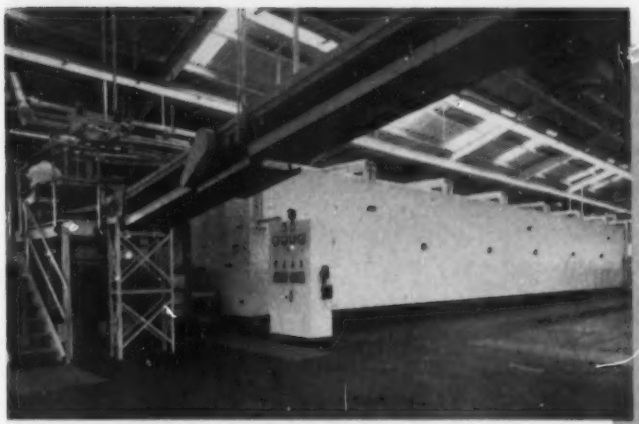
THE GRISCOM-RUSSELL CO.
MASSILLON, OHIO
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

G-R
HEAT TRANSFER APPARATUS

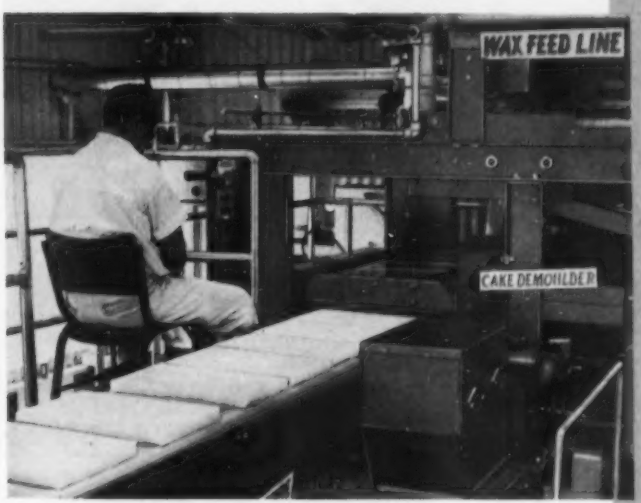
High-Temperature K-Fin

WAX PRODUCERS

take the labor and floor space out of wax moulding



15,000 lb./hr. GREER Moulder installed at prominent East Coast refinery.



Machine Discharge Station with complete control over operation and inspection.

WRITE
Helpful, informative 9-page bulletin tells how a GREER Moulder saves labor and space; ups quality control.

. . . CONSIDER THESE ADVANTAGES WHICH A **GREER** AUTOMATIC WAX MOULDER GIVES YOUR PLANT:

AMAZING LABOR SAVINGS
. . . because one man and a Greer Moulder can slab up to 15,000 pounds of wax per hour. Users report labor savings of up to 85%.

SPACE SAVINGS, TOO
Automatically deposits, cools, and demoulds, all in approximately 1/10th the floor space ordinarily required by batch processes of equal capacity.

PRECISE WEIGHT CONTROL
Volumetric Depositor holds cakes within ±½ of 1% in weight for a given setting. Saves spot checking labor. No air entrapment.

SANITARY
Wax is untouched from time it leaves storage tank to finished cake.

●

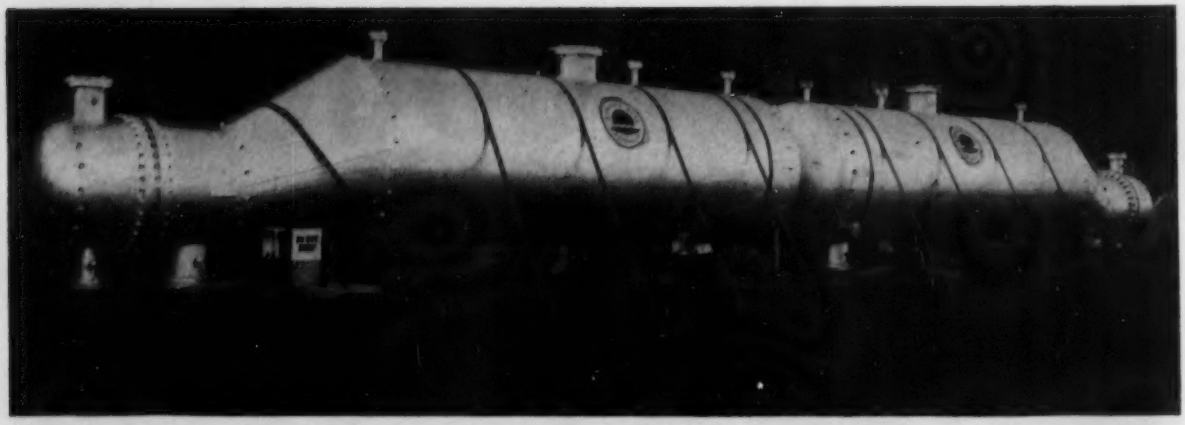
NOW AVAILABLE
New 2500-7500 lb./hr. model (10-pound cakes) in addition to standard 7500-15000 lb./hr. GREER Wax Moulder.

J. W. GREER COMPANY

WILMINGTON, MASSACHUSETTS
Sales Engineering Offices: Chicago, Ill., San Francisco, Calif.

GREER

For more data on advertised products, use Readers' Service Cards, last page.



Ross Exchangers
REACH YOU FASTER!

Leaving the Kewanee, Ill. works, these Ross Exchangers and Kettle Type Reboilers will travel the shortest possible routes to their new owners. Naturally!

But that's merely a matter of days or hours . . . hardly enough to talk about when one considers the time that Kewanee-Ross can often by-pass in engineering and fabrication.

Yes, it's a fact that Ross Exchangers and Condensers can stop the clock . . . *in a number of ways* . . . from the time you first consult with a Kewanee-Ross engineer until your product is delivered. (1) A great variety of standardized designs, in numerous sizes, often provide immediate solutions. (2) No matter how individualized, specially engineered units can frequently utilize many standard components and design features. (3) Unique experience over many years, in meeting greatly diversified requirements, is bound to include a "case" that closely parallels yours.

Make sure that your next exchangers and condensers reach you faster by consulting Kewanee-Ross early.

KEWANEE-ROSS CORPORATION
DIVISION OF AMERICAN RADIATOR & STANDARD SANITARY CORPORATION
1419 WEST AVENUE • BUFFALO 13, N. Y.
In Canada: Kewanee-Ross of Canada Limited, Toronto 5, Ont.

ROSS

Serving home and industry: AMERICAN-STANDARD • AMERICAN BLOWER • CHURCH SEATS & WALL TILE • DETROIT CONTROLS • KEWANEE BOILERS • ROSS EXCHANGERS • SUNBEAM AIR CONDITIONERS

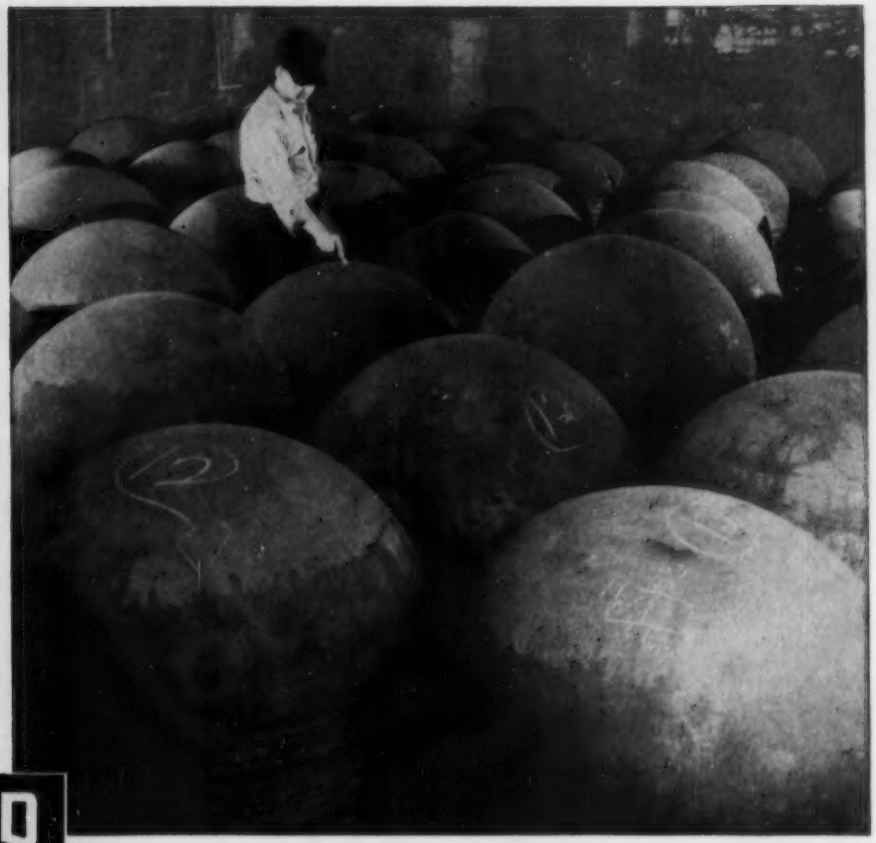
THIS cowboy thought he could ride anything—until he was thrown by a Brahman bull, a critter no more discomforting than many a critical piping job. For such, our prefabricating facilities and installing experience both assure you that Mitchell will master your toughest problem from start to finish, saving you time and money. Send us your specifications.

W. K. MITCHELL & CO., INC.
Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS



SHEFFIELD
ARMCO

How Sheffield Steel Serves a Booming Market

The Liquefied Petroleum industry is flashing one of the most phenomenal growth records on the industrial scene today. From one million in 1940, consumers of this heat-rich, clean fuel have multiplied to nine million.

Along with matching Sheffield steel plate for forming into tank shells, the deep drawn, semispherical Sheffield tankheads pictured go to tank manufacturers across the nation.

The uses of LP gas are numerous and expanding. On the farm, it performs such chores as cooking, heating, refrigeration, machinery and tractor propulsion, crop drying and weed-burning—and now air conditioning.

In addition to this growing LP gas market for these pressure vessels made of Sheffield steel components, another big potential market looms up in the handling of liquid fertilizer. It seems a certainty the demand for pressure vessels will continue. If you have an active interest in this booming industry let us tell you how we can serve your need.

Look to Sheffield

for Quality Carbon and Alloy Steels Needed In Products of Your Manufacture—Ingots, Blooms, Billets, Plate, Structurals, Merchant Shapes, Manufacturers Wire, Bolt and Nut Products, including Structural Bolts.

SHEFFIELD STEEL
DIVISION
ARMCO STEEL CORPORATION
SHEFFIELD PLANTS: HOUSTON • KANSAS CITY • TULSA

Is A Control Valve Always A Control Valve?

Yes . . . but not necessarily a conventional control valve. The Conoflow EB Current Controller—a unique final control element—is an electric valve which controls *at the source* rather than in the line. This is the perfect solution for handling extremely viscous flows or when corrosion or abrasion presents a tough problem. In many services too, it offers a more economical approach to fluid control than by means of a conventional control valve.

The Cono EB Current Controller is essentially a pneumatic-electric transducer. It consists of the proved Conoflow Cylinder Conomotor and an electrical component such as a rheostat, potentiometer or autotransformer. The Cylinder, operating from a 3-15 psi air signal, produces precisely regulated rotary motion (to 360°) of the electrical component to control voltage, current, inductance, capacitance, resistance or other electrical values.

A widely used method of regulating fluid flow with an EB unit is to position a rheostat in the motor field or armature circuit as a direct function of the pneumatic signal pressure. On many applications, electronic speed changers and electric motors can be controlled from zero to full capacity, offering a resultant control range that cannot be matched by conventional control valves.

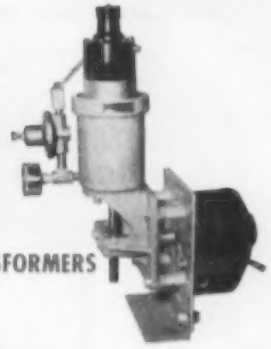
Conoflow EB Current Controllers are available in over 200 combinations of electrical components to handle a wide variety of applications. A few are suggested here:

Constant Pressure	Constant Temperature
Proportional Flow	Boiler Feed Water Control
Liquid Level	Rewind Control
Machine Tool Speed	Constant Flow
Conveyor Control	Stoker Feed Control
Heat Treating	Humidity Control

The Conoflow EB Current Controller provides automatic feedback control with these electronic speed changers:

Louis Allis—*Select-A-Spede*	Reliance—*V.S. Drive*
Brown-Brockmeyer—*Dial-A-Speed*	Servo-Tek Products—*Servo-Tek*
General Electric—*Thy-Mo-Trol*	Weltronic—*Vara-Speed*
Master Electric—*Speedranger*	Westinghouse—*Mot-O-Trol*

WRITE TODAY FOR BULLETIN EB-1. Tell us something of your process control problem. Chances are we can suggest from direct experience an installation that would be profitable to you. No obligation, of course.



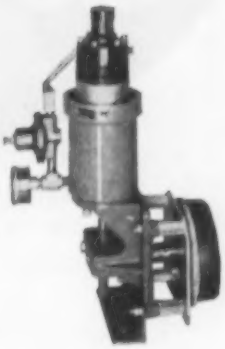
General Radio (Variac)

AUTOTRANSFORMERS

Superior Electric (Powerstat)

RHEOSTATS

Cutler Hammer
General Electric
Ohmite
Ward Leonard
Westinghouse



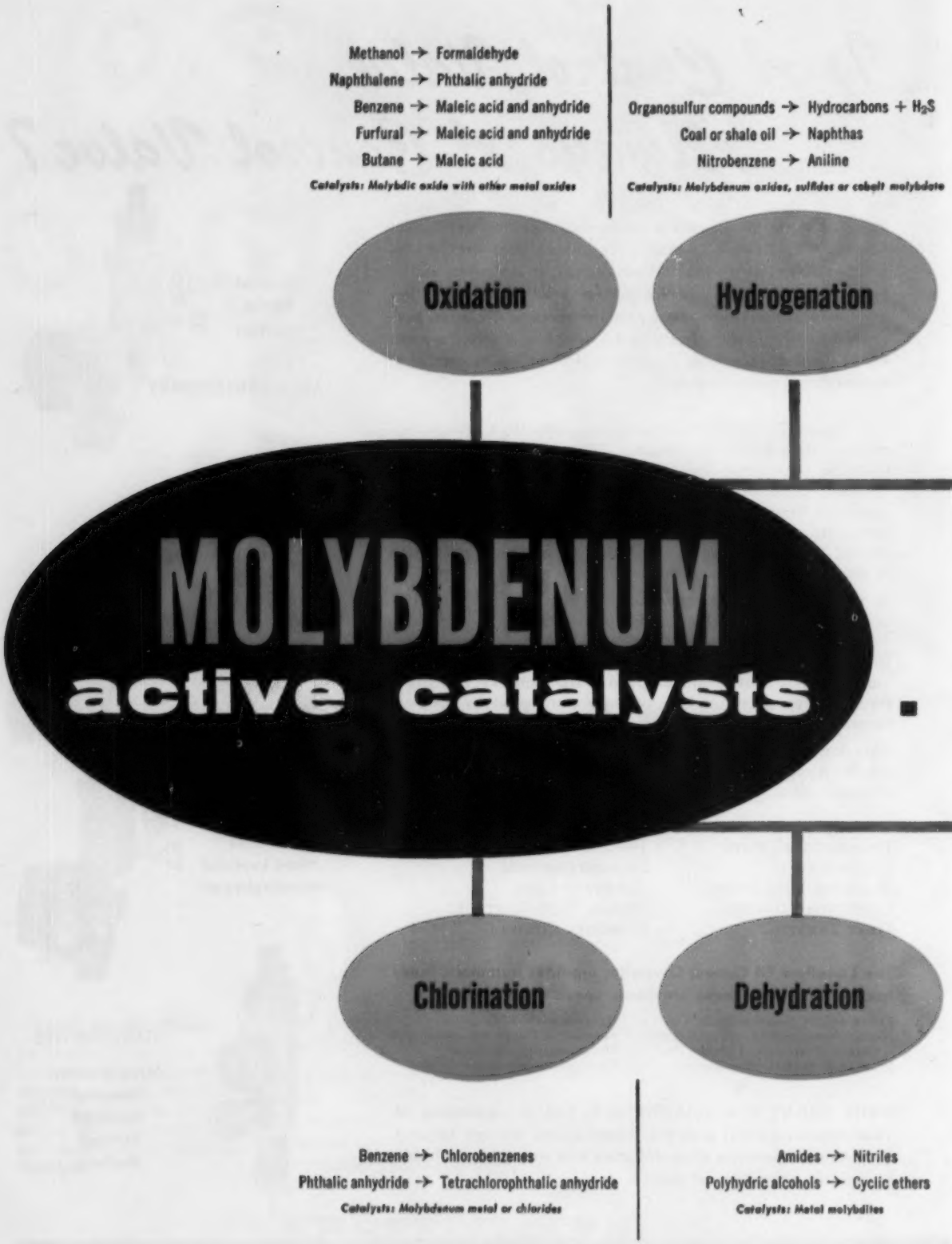
POTENTIOMETERS

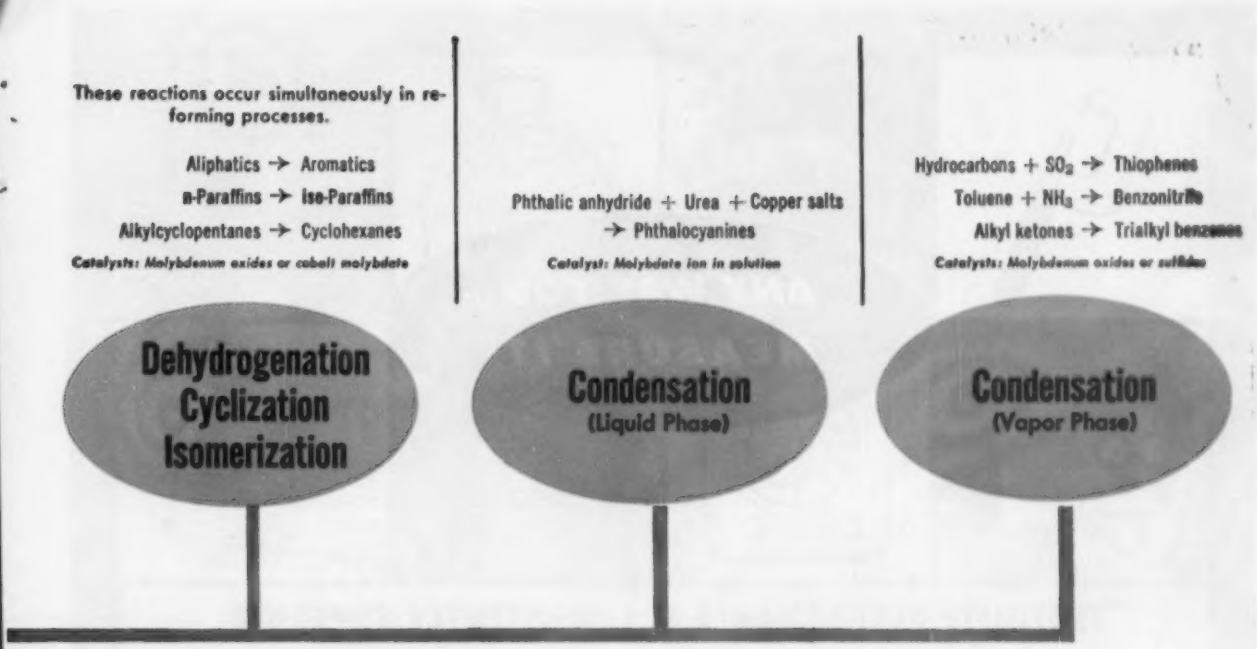
Allen-Bradley
Clarostat
Fairchild
Helipot
Mallory

CONOFLOW CORPORATION
FOREMOST MANUFACTURERS OF FINAL CONTROL ELEMENTS
2100 ARCH STREET, PHILADELPHIA 3, PA.

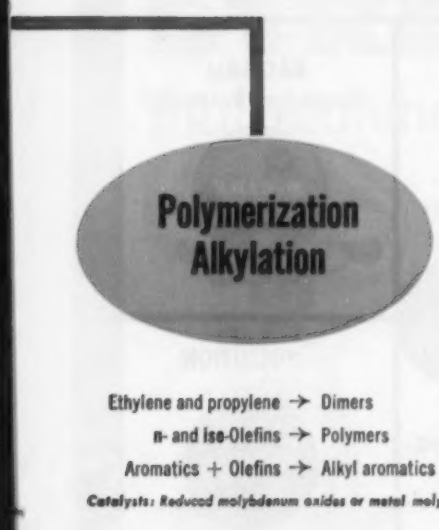
Cono-Controls®

For more data on advertised products, use Readers' Service Cards, last page.


Methanol → Formaldehyde
Naphthalene → Phthalic anhydride
Benzene → Maleic acid and anhydride
Furfural → Maleic acid and anhydride
Butane → Maleic acid
Catalysts: Molybdic oxide with other metal oxides
Organosulfur compounds → Hydrocarbons + H_2S
Coal or shale oil → Naphthas
Nitrobenzene → Aniline
Catalysts: Molybdenum oxides, sulfides or cobalt molybdate
Oxidation
Hydrogenation
MOLYBDENUM
active catalysts
Chlorination
Dehydration
Benzene → Chlorobenzenes
Phthalic anhydride → Tetrachlorophthalic anhydride
Catalysts: Molybdenum metal or chlorides
Amides → Nitriles
Polyhydric alcohols → Cyclic ethers
Catalysts: Metal molybdites



. for many reactions


Polymerization
Alkylation
Ethylene and propylene → Dimers
n- and Iso-Olefins → Polymers
Aromatics + Olefins → Alkyl aromatics
Catalysts: Reduced molybdenum oxides or metal molybdites

Selectivity, resistance to poisons, and high activity make molybdenum catalysts the preferred materials for a variety of commercial processes. Laboratory and pilot plant studies show promising results in many other reactions.

Molybdenum catalysts might be just the answer to your special needs. Why not give them a try! For data on the applications shown here write for our new bulletin "Molybdenum Catalysts."

Address: Climax Molybdenum Company, Department 26, 500 Fifth Avenue, New York 36, N. Y.

MC 5-12

CLIMAX MOLYBDENUM

For more data on advertised products, use Readers' Service Cards, last page.

ANY WAY YOU MEASURE IT

TRETOLITE PERFORMANCE IS CONSISTENTLY SUPERIOR

TRETOLITE COMPANY
A DIVISION OF PETROLITE CORPORATION
369 Marshall Avenue, St. Louis 19, Missouri
5515 Telegraph Road, Los Angeles 22, California

TRETOLITE'S CONSISTENTLY SUPERIOR PERFORMANCE IS AVAILABLE TO THE INDUSTRY IN PROBLEMS CONCERNING . . .

EMULSIFICATION
Demulsifiers

SCALE
Scale Preventives

CORROSION
Corrosion Inhibitors

BACTERIA (Secondary Recovery)
Bactericide

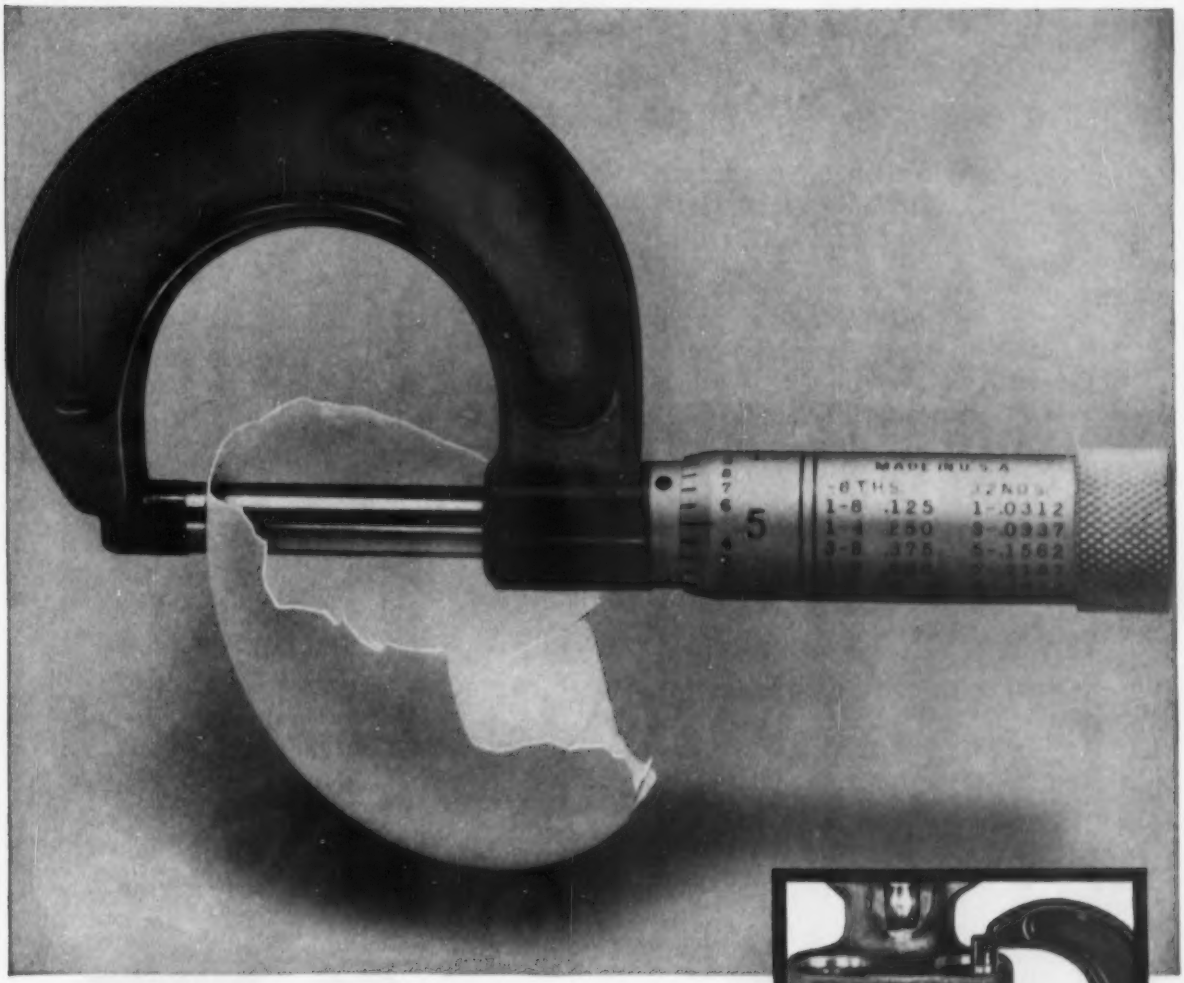
TRETOLITE SERVICE IS THE KEY TO SUPERIOR PERFORMANCE

WATER/MUD BLOCKS
Production Stimulator

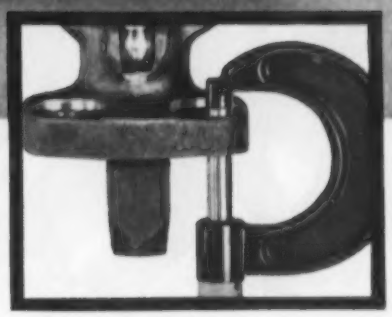
SALT
Desalting

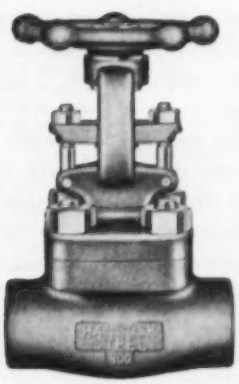
ASPHALT STRIPPING
Asphalt Additive

POLLUTION
Water De-Oilers



STRENGTH
that matches the purpose





THE BONNET FLANGES on the Type 950 Hancock Steel Gate Valve combine compactness with rugged strength *where strength is needed most*. Flange thickness and bolting provide sturdiness that can withstand more than ten times the rated pressure of the valve. Butting of the flange faces eliminates every possibility of bending and distortion.

In revalving old, or installing new process and power piping systems, the enduring strength of Type 950 Hancock Steel Gate Valves always proves there is no substitute for the economy of quality. Get complete facts. Phone your Industrial Supply Distributor today.

HANCOCK VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Watertown 72, Massachusetts

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

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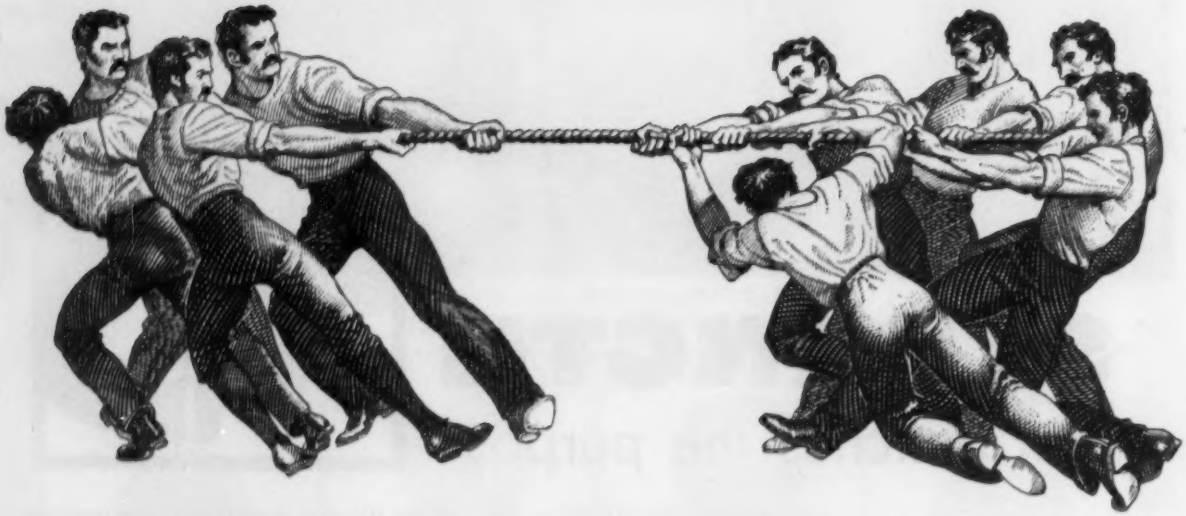
boost production
with the Ljungstrom® Air Preheater

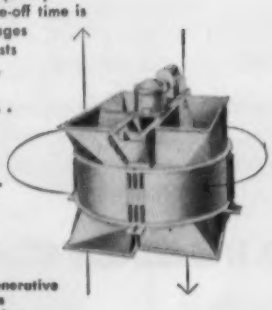
4 *of your units*
can do
the
work of 5



HOW FAST IS "WRITE OFF"?

In most cases, the Ljungstrom installation is quickly written off by increased capacity alone. Write-off time is even less when the other Ljungstrom advantages are considered—saves up to 20% of fuel costs . . . permits more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . results in consistently higher through-put . . . and minimizes slag.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write The Air Preheater Corporation.



Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

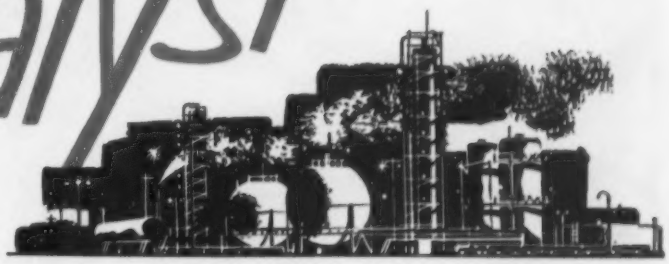
Recover waste heat, return it to the furnace as combustion air, and you naturally generate higher flame temperatures . . . increase heat-transfer rates—*which means more through-put.*

That's why four of your present processing units can do the work of five *with Ljungstrom Air Preheaters increasing each unit's output as much as 25%.* One eastern refinery increased the continuous capacity of a pipe still from 16,000 to 18,000/20,000 barrels a day—by modernizing and including a Ljungstrom.

The Air Preheater Corporation **60 East 42nd Street, New York 17, N. Y.**

Davison M-S®

HIGH ALUMINA Catalyst



DAVISON GIVES YOU HIGH ALUMINA CATALYST IN THE PARTICLE SIZE BEST SUITED FOR YOUR UNIT!

HIGH ALUMINA M-S CATALYST PARTICLE SIZE DISTRIBUTION

The catalyst with a *minimum of fines* . . .

Grade	F-3-25 Extra Fine	F-2-25 Fine	F-1-25 Inter-mediate	C-1-25 Coarse	C-2-25 Extra Coarse
Size range by C.A.E.: Wt. %					
0-10 Microns	4	2	1	1	1
0-20 Microns	9	4	2	2	2
0-30 Microns	16	11	6	5	4
0-40 Microns	28	21	12	10	8
. . . and a *minimum of coarse particles*					
Sieve analysis: Wt. %					
on 100 mesh (149 microns)	0	0	1	1	1
on 140 mesh (104 microns)	1	1	4	6	8
on 200 mesh (74 microns)	4	5	15	22	33

Now Davison has taken the characteristics of High Alumina Catalyst and combined them with the proven advantages of its 13% Alumina Catalyst. This gives you, for the first time, High (25%) Alumina Catalyst with *all* these qualities:

- ***Lower Stack Losses***
- ***Better Maintenance of Activity and Surface Area***
- ***Narrow Particle Size Distribution***
- ***High Attrition Resistance***
- ***High Purity and Uniformity***

For information on Davison High Alumina Catalyst see your Davison Representative or write.

Progress Through Chemistry

DAVISON CHEMICAL COMPANY

Division of W. R. Grace & Co.

Baltimore 3, Maryland

Sales Offices: Chicago, Ill.; Houston, Tex.; New York, N. Y.; Baltimore, Md.
Davison Chemical Company, Ltd., Toronto 1, Ontario, Canada

PRODUCERS OF: CATALYSTS, INORGANIC ACIDS, SUPERPHOSPHATES, TRIPLE SUPERPHOSPHATES, PHOSPHATE ROCK, SILICA GELS AND SILICOFLUORIDES. SOLE PRODUCERS OF DAVCO® GRANULATED FERTILIZERS.

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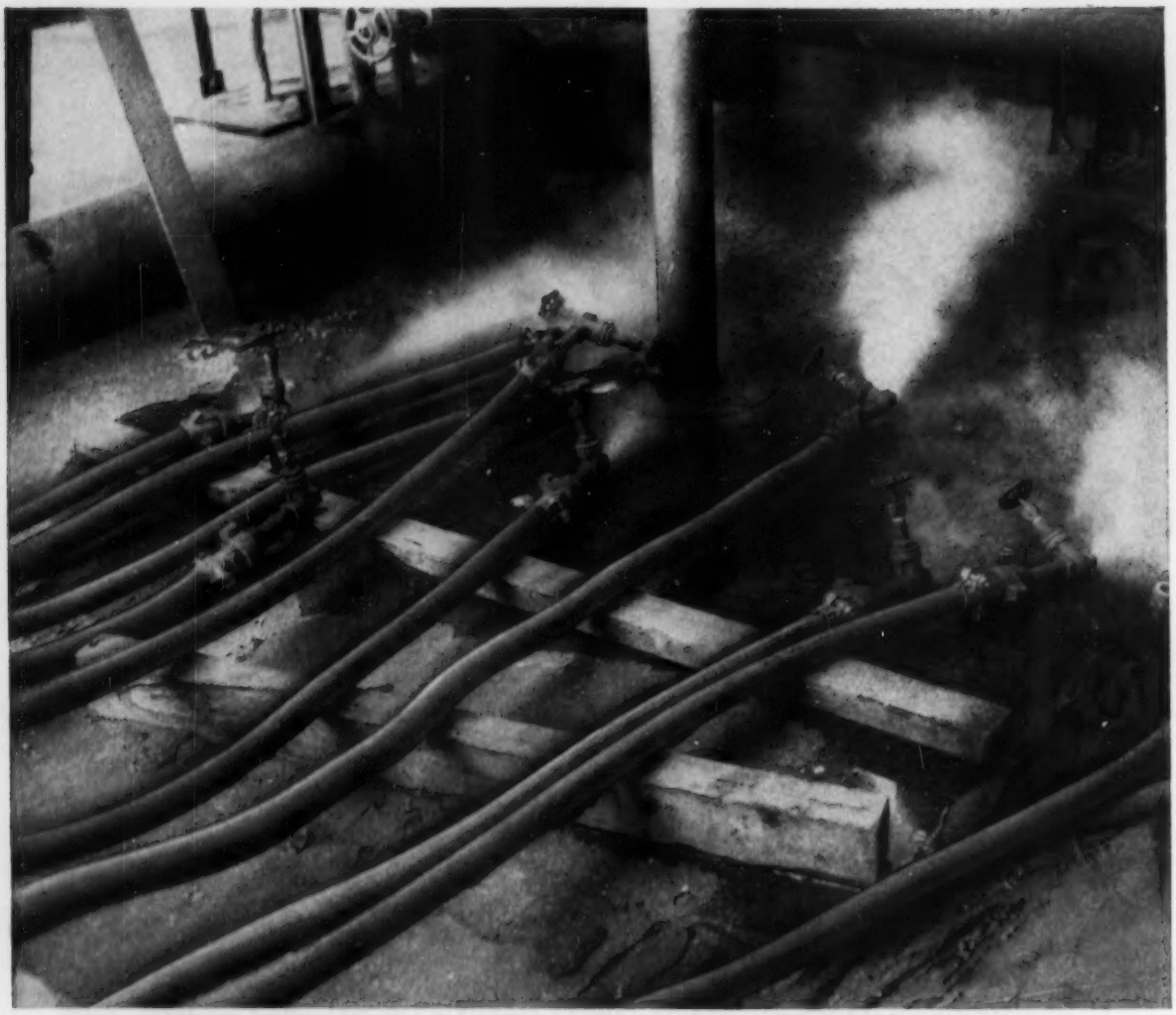


For Real Insurance Against Danger of Bursting Hose

For general steam service Ironsides-Victor is widely accepted as the strongest, safest hose available. Its superiority is due to its construction.

Ironsides-Victor is braided with steel wire, bonded with rubber, and has an extra braid of glass cord for insulation and added strength. There is absolutely no cotton used in this hose. The tube is of a special compound that resists very high temperatures — even up to 388° F.

Because of its extra-tough, extra-thin wall construction, this hose is lighter, more flexible, and easier to handle than any other steam hose . . . and it's kink-proof.

Ironsides-Victor is at least four times stronger than wrapped fabric steam hose, yet costs no more. For safe, efficient, economical service—specify Ironsides.

Available in I.D. sizes ½" to 2½", in 25 and 50-ft. lengths, with interlocking, high pressure type couplings.

We also manufacture a complete line of industrial rubber products: hose, belting, packing and moulded rubber of every construction for every need. *Through your Quaker and Quaker Pioneer distributor* our research and engineering services are always available to help you solve any industrial rubber problem. *Write for free folder and name of nearest distributor.*

QUAKER RUBBER CORPORATION
Philadelphia 24, Pennsylvania

HKP

QUAKER PIONEER RUBBER MILLS
San Francisco 7, California

STANDARDIZE ON THIS FITTING AND YOU'LL REDUCE INVENTORY...SAVE MONEY...

it's the NEW 5000 TYPE KEY® RETURN BEND FITTING

WITH HIGH DEGREE OF INTERCHANGEABILITY

TWO SERIES:
850 and 1275 LBS.
NINE FITTINGS
in each series

A TOTAL OF 18 FITTINGS, BUT REQUIRING ONLY 26 PARTS INSTEAD OF 72

HEADING UP OPERATION
Holding member and screw may be handled as a unit.

UNHEADING
A slight loosening of the screw permits holding member and screw to be removed as a unit. The stem has been designed to withstand plug removal by striking with a hammer.

SAFETY FEATURE
Plug can be loosened before a holding member is disengaged, preventing the possibility of the plug blowing out of fitting as the result of build up of back pressure.

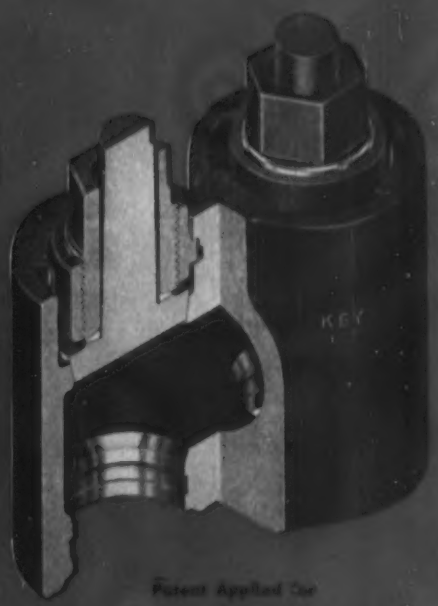
DAMAGED PARTS
If threads become damaged or frozen, holding mechanism can be removed by turning the breech.

STRESS DISTRIBUTION
Elliptical crossovers in the 5000-type give a maximum uniform distribution of stress. Plug hole section will be more uniformly stressed because of the added support of the 360° projection immediately above the plug seat.

METAL IN TENSION
The tension load is evenly distributed throughout the 360° circular projection.

SHEAR
The shear load is evenly distributed over 180°.

BENDING
No bending can occur in the holding member and the full 360° projection above the plug seat prevents bending of the lugs.



Patent Applied For

850 lb. and 1275 lb. series

Fitting Size	Plug Number	Holding Member Number	Screw Number	Thrust Ring Number
2½	5Y1	2Y1	9Y1	D-13011
3	5Y2	2Y2	9Y2	D-13012
3½	5Y3	2Y3		
4	5Y4	2Y4		
4½	5Y5	2Y5	9Y3	D-13013
5	5Y6	2Y6		
5½	5Y7	2Y7		
6	5Y8	2Y8	9Y4	D-9356
6½	5Y9	2Y9		

All parts of the 5000-type fitting, exclusive of the body casting, are available for immediate shipment from stock.

Write for information and prices now

key company

Since 19[illegible] . . . manufacturers and developers of product[illegible] for high temperatures and pressures

P.O. BOX 494-E EAST ST. LOUIS, ILLINOIS

DISTRICT OFFICES: NEW YORK • CLEVELAND
CHICAGO • [illegible]

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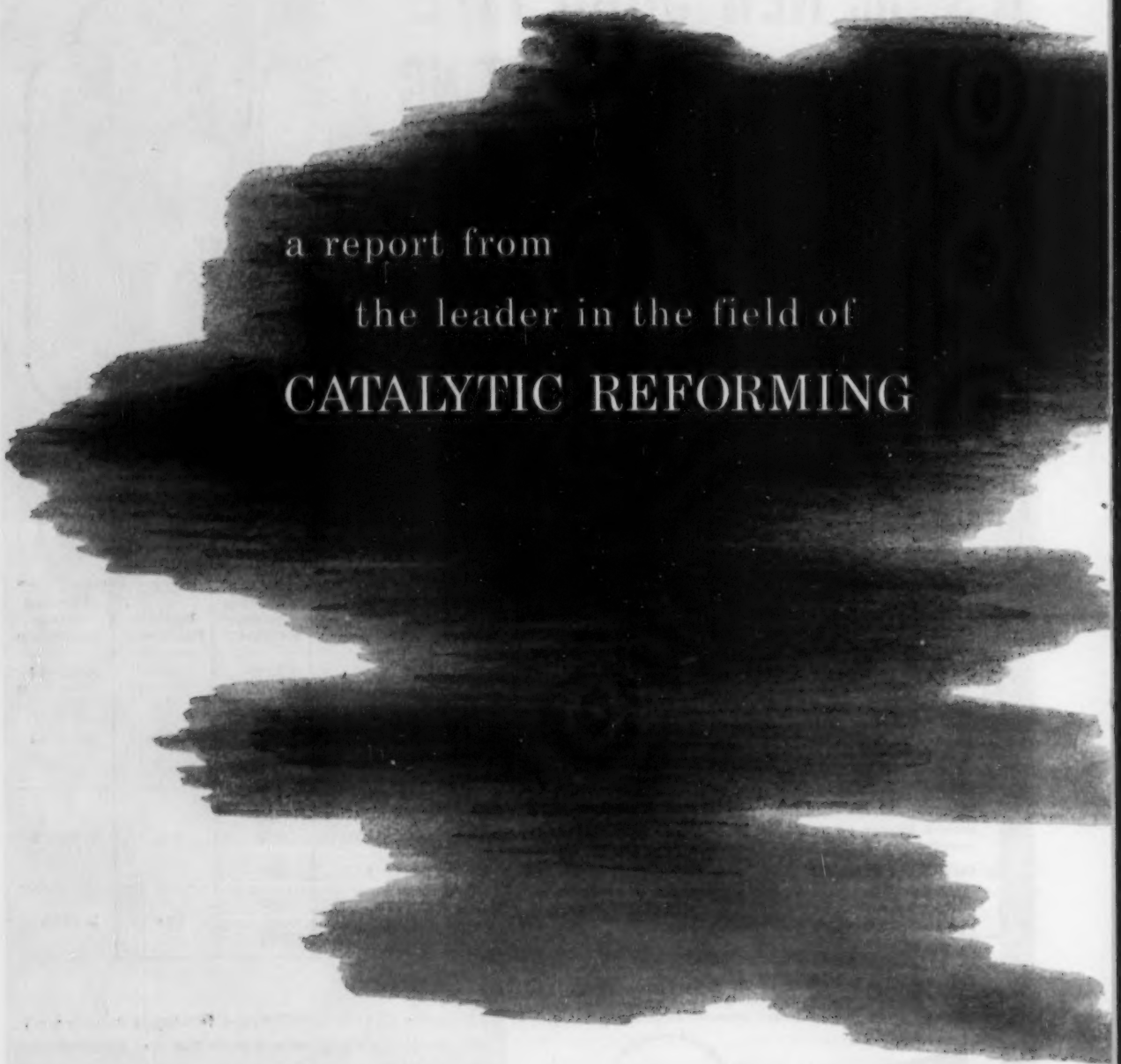
a report from
the leader in the field of
CATALYTIC REFORMING

MUCH HAS TRANSPIRED since Universal Oil Products Company announced in March, 1949, the availability of Platforming—the catalytic reforming process which pioneered the use of a platinum catalyst and which established catalytic reforming as one of the basic refining processes. Just seven months after this announcement, the first commercial unit was placed on stream. Since that time the process has received an unsurpassed acceptance throughout the world's petroleum refining industry.

The unprecendented recognition given to this catalytic reforming process is indicative of how well it has fulfilled the industry's need for an economical and efficient method to up-grade low-quality napthas. Platforming's adaptability is brought out in the sizes of the units which have been installed. With capacities ranging from 500 to 29,000 barrels, the UOP Platforming process has proved to be an answer to refiners' octane problems, no matter what the scope of their operations might be.

Recognizing that the ever-increasing demands for higher octanes would place additional burdens on the petroleum refining industry, Universal continued its studies in catalytic reforming. The results of this work were announced last March, with the introduction of Rexforming.

This newest catalytic reforming process will permit refiners to produce fuels of any useful octane rating, without limitations due to feed stocks. Laboratory and pilot plant tests have shown Rexforming to be capable of producing gasolines in excess of 100 clear octane.

Commercial acceptance of Rexforming has been immediate. Units are now being engineered and construction on these installations is scheduled to begin shortly.

The future for catalytic reforming is certainly one of continued growth and progress. It is a future in which Universal Oil Products Company will play a leading role.

UNIVERSAL OIL PRODUCTS COMPANY

UOP

30 ALGONQUIN ROAD,
DES PLAINES, ILL., U. S. A.

Universal Service Protects Your Investment

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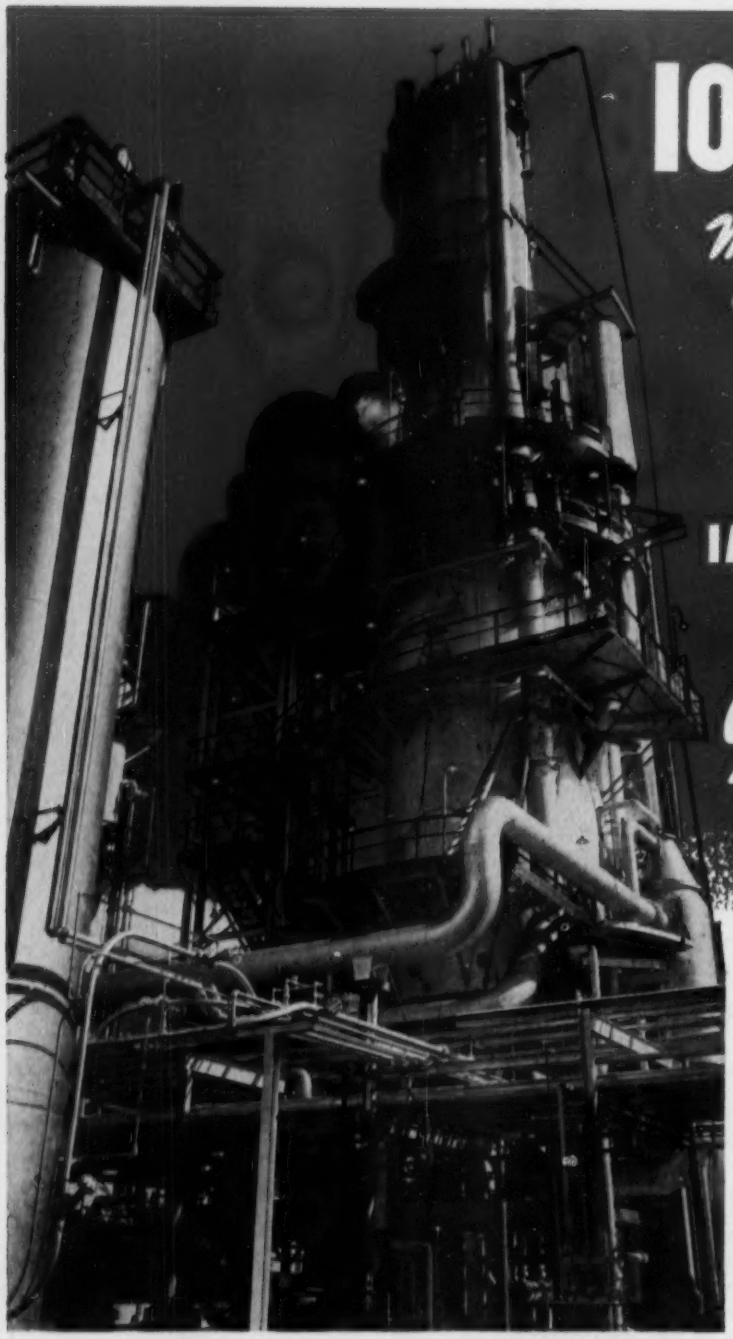


100 octane +

Meet the Challenge of Competition With

QUALITY IMPROVEMENT

of YOUR gasoline!

The demand for higher octane gasoline is increasing rapidly and it is only a matter of time until you will be faced with meeting the challenge of 100 octane (plus) gasoline. Our prediction is that it will be earlier than you think.

Treco would like to help you, too! Get started now, in advance of competition. Call us to discuss your requirements. Remember . . . Treco designs, engineers and constructs — f a s t.

TRECO

REFINERY ENGINEERING *Company*

TULSA TORONTO

The Mail Box . . .

Supplements Article On Ammonia Materials

To The Editor:

Having had a long background in the design and operation of various ammonia synthesis processes, perhaps I may be able to contribute something to supplement the information in the article, "How to Choose Materials of Construction for Ammonia Synthesis," in the June issue of Petroleum REFINER. Actually, if there is an understanding and an appreciation of the conditions of service, this isn't too difficult. Most of the older literature should be disregarded.

As you stated, a cooling pass is generally used in the reactor units, and this is even so in the latest design of the Claude process, so that high temperature should not be a factor in the selection of the material for the reactor. Under 200 C, hydrogen attack does not occur at the pressures used in ammonia synthesis and, with a good reactor design, it should be possible to place the hand on the surface of the reactor without a feeling of discomfort. Of course, this is not the case adjacent to the gas exit connection. The problem, therefore, is simply a matter of selecting for strength properties, depending upon the operating pressure. At one time it was considered necessary to use a chrome-vanadium steel (3½% Cr. 0.18% V), or better, but this specification was discarded years ago.

Where temperatures are at the maximum, 450 to 600 C, in the catalyst cartridge, the material problem is of a different nature. Here, although the pressure is insignificant, hydrogen and ammonia are the bad actors. It is questionable whether molecular nitrogen causes trouble but the conditions are ideal for nitriding by ammonia. A straight 6 percent chrome steel will become as brittle as glass in a very short time. Where conditions are relatively mild, such as at 450 C. and 5000 psi, even low carbon steel has given reasonably good service. With the higher pressure processes, however, it is advisable to use the higher alloy steels for the catalyst cartridge. Copper, as was indicated, is good where it can be used but it must be thoroughly deoxidized.

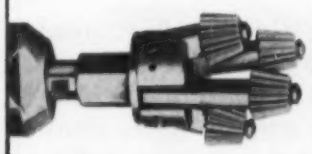
Carbon steel high pressure tubing of a weldable quality is adequate in most cases, if the temperature does not exceed 200°, and up to 300° a 1 percent chrome steel, SAE 6120, will suffice. Wherever possible, tubing should be welded rather than using a gasketed joint because every joint is a potential source of leakage.

Fatigue failures are the result of pressure fluctuations and the number of cycles and are usually confined to the compression equipment. As a rule, very little trouble from this source is experienced under 5000 psi but at higher pressures, where the stress range is often increased, more care should be used in designing to eliminate stress raisers. For this reason welding should be avoided because it is almost impossible to tell where there is a slight flaw which may be a point of stress concentration. This may sound contradictory to the statement in the preceding paragraph but pressure variations after the discharge of a compressor are so small as to be insignificant. Perhaps 90 percent of the welds in tubing would fail in a matter of hours if they were subjected to the pressure changes that

When coke is stubborn— ...TRY LAGONDA

The famous Lagonda 1100 Series refinery motor, with Type UO cutter head. A widely used combination.

For tubes of wide tolerance – the Long-Surface Swing Frame head.



For tough, uneven coke – the Type H-2 head.

FOR CONDENSERS AND HEAT EXCHANGERS

Direct-drive air or steam driven cleaner with long shaft, the motor supported outside the tube by overhead pipe. Motor has trigger control. Also available with electric motor.

Occasionally you run into a brand of coke that laughs at everything you've got in cleaning equipment. Something different is indicated, and often that something is a change to Lagonda 1100 Series cleaners armed with a tough-slugging Lagonda head selected on the basis of Lagonda "know-how"—usually a pretty successful combination, and certainly worth trying when the time-out bill is climbing.

Lagonda cleaners have been on the job ever since the first still started up, and Lagonda engineers are veterans of many a tough coke battle. This experience is at your service. Phone your local Lagonda man, or write Elliott Company, Springfield, Ohio. Try Lagonda—it may well be the right answer.

ELLIOTT Company

Y4-3

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

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Confident steps...

where 40 steel diamonds grip every foot

Men and rolling equipment move safely—without danger of slipping—over economical SUPER-DIAMOND floor plate. Every single diamond —40 of them to a step—guards constantly against skids and slips.

Easy to fabricate and install, this non-directional pattern rolled-steel floor plate provides low-cost safety and rugged durability. SUPER-DIAMOND floor plate won't trap dirt—cleans and drains quickly—gives many years of dependable safety under the heaviest industrial loads.

Mail the coupon below for information on this low-cost, long-lasting rolled-steel floor plate.

A.W. SUPER-DIAMOND ROLLED STEEL FLOOR PLATE

"The diamond in the rough . . . a gem of a flooring."

ALAN WOOD STEEL COMPANY
Conshohocken, Pa.

Please send A.W. SUPER-DIAMOND Booklet SD-27

Name_____

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Address_____

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Other products: A.W. ALGRIP Abrasive Rolled Steel Floor Plate—Plates—Sheets —Strip—(Alloy and Special Grades)

For plants where oil, water and grease raise special problems of slipping accidents, we suggest a check on the special qualities of A.W. ALGRIP . . . the world's only abrasive rolled steel flooring.

The Mail Box . . .

occur in a compressor cylinder but they would be good indefinitely at constant pressure.

Much more could be said on this subject but it sounds simple, doesn't it?

Walter Coopey
Engineering Consultant
Charleston, W. Va.

Response by Authors

The comments of M. Coopey provide a valuable supplement to our article on materials for ammonia synthesis. The introduction of the cooling pass next to the reactor shell in the latest design for the Claude process cylinders should eliminate the necessity for the nickel-rich iron-chromium-tungsten alloy previously used.

Straight 6-percent chromium steel will become embrittled at 500 C. in the absence of nitrogen or ammonia. The addition of molybdenum reduces this tendency. Developing the complete glass brittleness Mr. Coopey mentions, of course, depends on the thickness of the metal, and the temperature and pressure involved. The hard brittle nitride layer provides somewhat of a barrier to the further inward diffusion of nitrogen.

We have heard of the use of low carbon steel at 5000 psi and 450 C. We are also aware of it having failed miserably under these conditions. Shell reports failure at 600 psi. H_2 partial pressure and 315 C.; M. W. Kellogg at 225 psi and 385 C. As Mr. Coopey says, it is advisable to use the higher alloy steels for the catalyst cartridge.

The suggestion of using low carbon or one percent chromium steel tubing in appropriate conditions is well taken. Operators will heartily agree with the warning about flanged joints leaking, and the desirability of welding. We would add that brazed joints are also used, and they solve the problem nicely where it is desired to join steel to copper.

We agree that most fatigue failures occur in components of the compression equipment, but would reiterate our suggestions on the use of damping devices anchoring piping and high quality welding beyond the compressors.

William G. Dudley and
John J. McKetta

Articles Invaluable

To the Editor:

Would you please send 15 reprints of your article on "Maintenance" as published in the March issue of PETROLEUM REFINER. These articles are invaluable and we intend to give a copy to each of our maintenance engineers, zone engineers and general foremen.

J. L. Huggett
General Superintendent
By: E. E. Dauphinee
Imperial Oil Limited
Sarnia, Ontario

A Fine Job

To the Editor:

You are to be congratulated on the very fine job you did on the motor fuel symposium in your April issue. I think the series did an excellent job in summarizing the major trends in the motor fuel field.

Henry Groppe,
Assistant Director,
Research-Development
Monsanto Chemical Company,
Texas City, Texas

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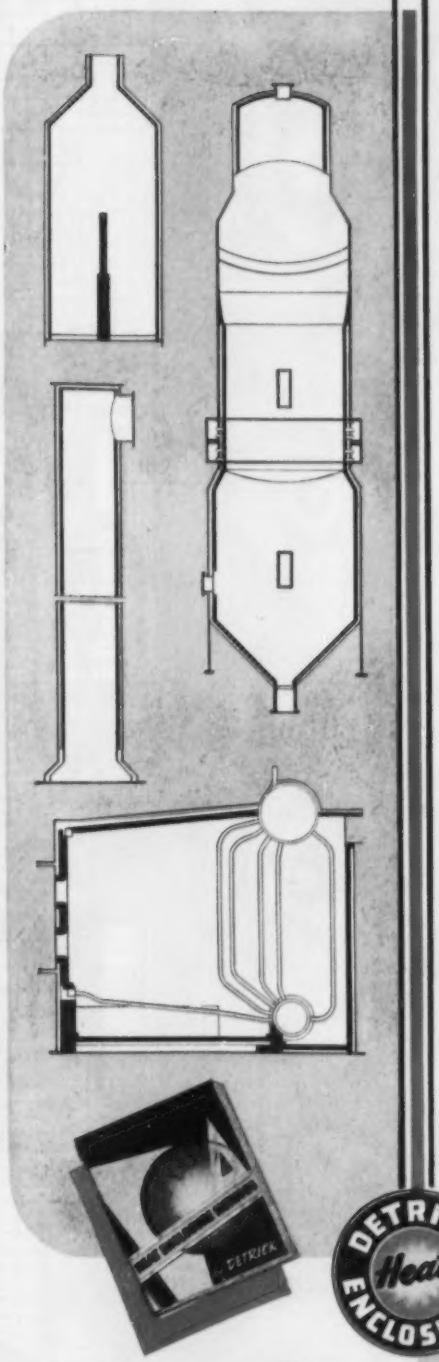
For Every Temperature and Operating Condition



Through the years Detrick engineers have been called upon to develop constructions that effectively meet every combination of conditions in heat enclosures.

In catalyst regenerators the abrasion must be considered together with low heat loss and gas tightness.

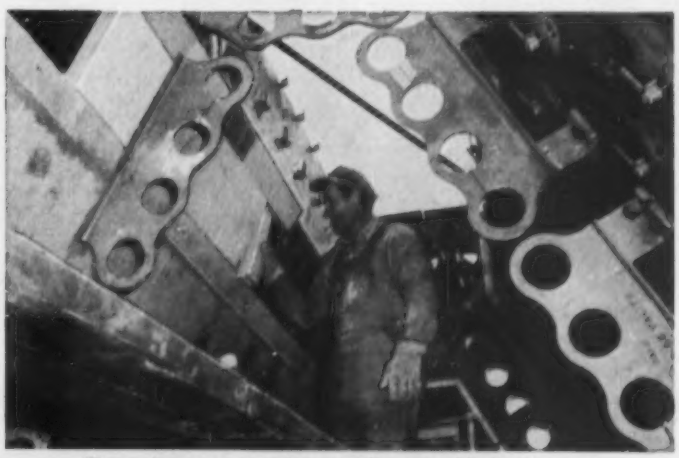
In boilers a heavier construction is necessary in the combustion area than in the upper areas. Detrick supplies the proper combination of design and materials to meet the conditions.

The contours and tube hangers in oil heaters present particular problems that have been handled by supported construction which takes the load off of refractories.

Sound engineering principles are demonstrated by the adaptability of Detrick constructions. For instance the Thermolayer construction is especially economical to apply to steel casings regardless of contour. It provides a refractory face backed by insulation and a poured layer which improves gas tightness.

If you have any problem involving heat enclosure get the benefit of Detrick's long engineering experience.

M. H. DETRICK COMPANY
111 W. Washington Street • Chicago 2, Illinois



Thermolayer construction permits assembly in the shop. Complete unit can be shipped to operating location.

SEND FOR BOOKLET
A complete story of the development of the art of enclosing heat is included in the new booklet entitled "HEAT ENCLOSURE METHODS BY DETRICK."

DETRICK Heat ENCLOSURES

DETRICK
HEAT ENCLOSURES

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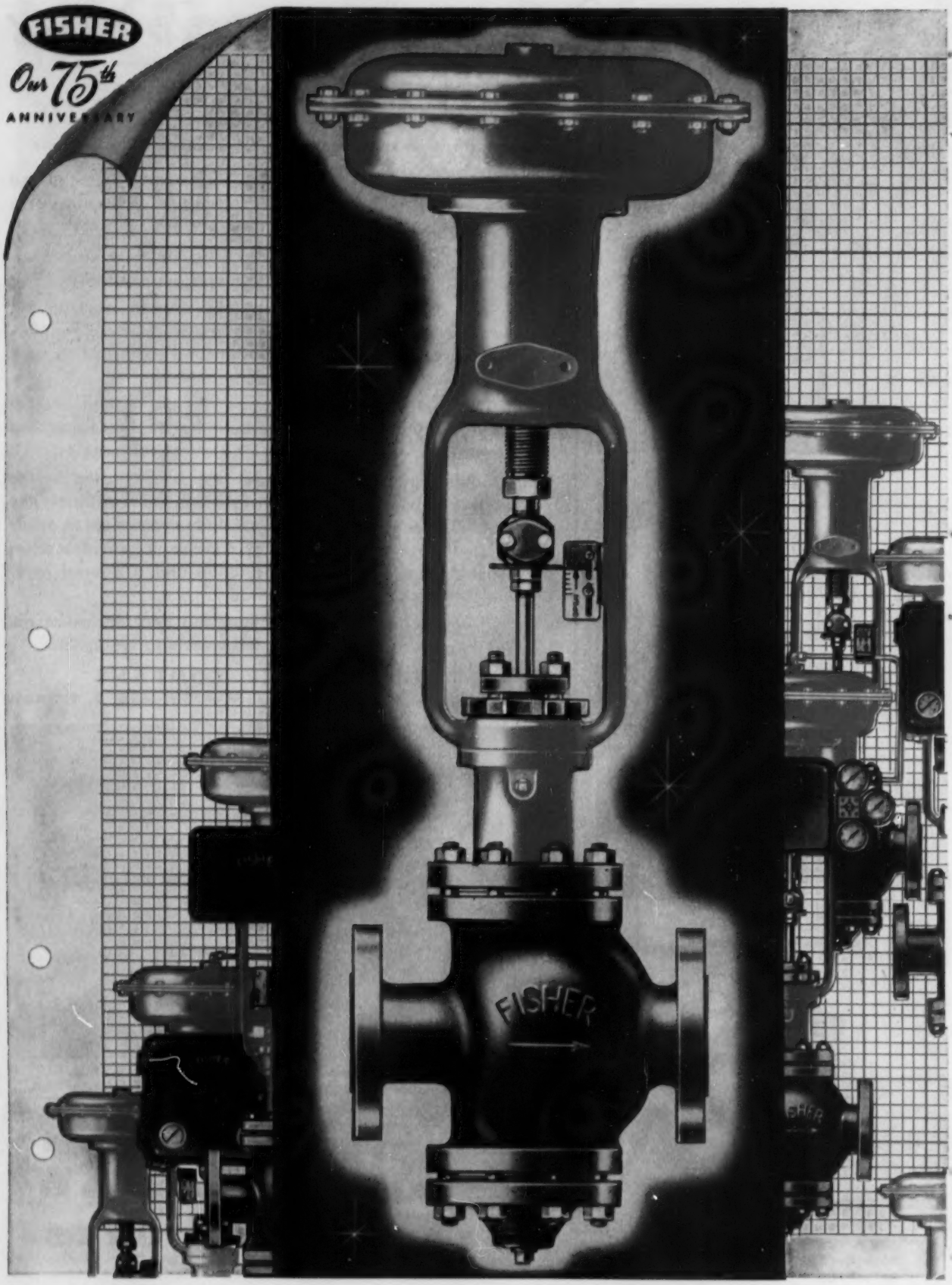
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Presents An Improved

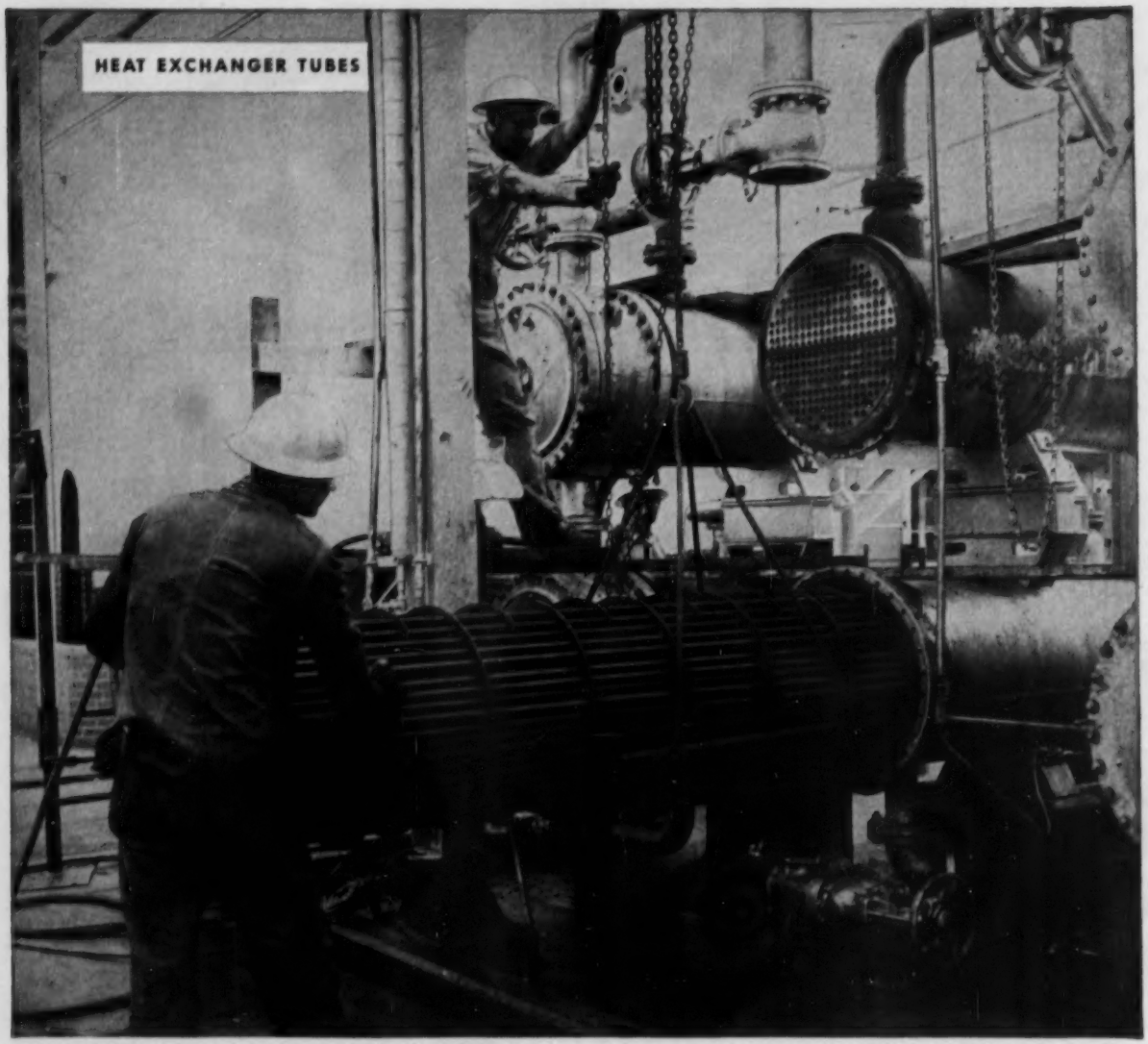
DIAPHRAGM MOTOR VALVE OPERATOR

Bolted-clamp type stem connection. This allows large latitude in valve stroke adjustment. It can be disconnected in the field without damage to the stem. It will not shake loose from vibration or rotational inner valve forces.

• Rugged body to yoke connection with hammer lug nut. • Deep drawn steel diaphragm casings. • Specially designed molded diaphragms. • Bolted gland stuffing box with Teflon packing. • Improved clear view travel indicator. • Spring ranges: 3 to 15 psi; 3 to 27 psi; 6 to 30 psi.

FISHER GOVERNOR COMPANY • Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL



PERFORMANCE RECORD of these tubes under actual operating conditions is now a part of Anaconda's extensive collection of case histories.

Use of Anaconda Cupro Nickel, 10%-755 Tubes in Texas refinery may answer your tube problem

Imagine a collection of tube performance case histories that can answer many of the corrosion problems you face!

Our files bulge with such a collection. Here is experience accumulated over almost a century. Here are detailed records of tube performance under hundreds of actual operating conditions.

We can put the information in these files to work for you at once—to help you select the one best alloy for your job.

Here's a case history we are now adding—the use of ANACONDA Cupro Nickel, 10%-755* Tubes in the Port Neches Refinery of a major oil producer.

These tubes—in use two years—cool heavy gas oil in an Alco Exchanger on a Crude Pipe Still Unit. Gas oil at about 500°F.—mildly corrosive—comes in contact with the outside of these tubes. Brackish river water—with a high salt content—circulates through the tubes. Yet the tubes show no sign of corrosion.

CUPRO NICKEL, 10%-755 resists corrosion almost as well as Cupro Nickel, 30%-702; yet it costs much less. Polluted sea water and sea water with entrained air—even at relatively high velocity—have little effect on this alloy.

Help for your tube problem. No one tube alloy serves best under all conditions. Your problem is one of choosing the right alloy for the job. Let Anaconda's Technical Department help you. Write, outlining your operating conditions, to Dept. TD, *The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*U.S. Patent No. 2,074,604 54109

ANACONDA®
Tubes and Plates
for Condensers and Heat Exchangers

A Quick Look at the Industry THIS MONTH

Petroleum REFINER
September, 1955

Recent moves by oil companies in field of atomic energy bid for some of glamour enjoyed by atomic power for generating electricity. Oil's approach is atomic radiation as processing tool to promote chemical reactions. Two such approaches have been announced: Esso is studying the use of radioactive cobalt; Atlantic and Shell are toying with electron accelerators.

Shell's van de Graaff accelerator, just purchased, is largest atom smasher in entire industry. It will be used to study effects of radiation on fuels, lubricants, plastics and other oil-deterived products. It's actually the second bought by Shell—first one being used in exploration research to study age of rocks. As a research tool, insurance companies do not classify the work as hazardous.

Atlantic sees great promise for its accelerator (termed an "electronic gun"), in reforming hydrocarbons for high-octane fuels—possibly five years off. Company's researchers have already produced hydrazine from ammonia with it, though yields have been very low.

These activities are just small part of what is being spent for atomic energy research, which can now be classified as "big business." Best estimate of such research costs to manufacturers, electric power companies, research institutions and other non-government organizations is $300 million in the next four years.

-•-

Giant new construction barge illustrates why smaller operators whose prototypes built U. S. drilling-producing industry are being virtually excluded from pioneering operations in offshore waters, which demand big companies, big money, big tools. Early this month Humble was to launch barge equipped with crane capable of picking up third of drilling rig at one time. Unit is 90 feet wide by 300 long by 20 deep and is equipped with two revolving cranes, one of 250-ton capacity and other of 40 tons. Equipment includes helicopter landing deck, living quarters for 58 men and eight 10,000-pound anchors to hold barge in position.

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Army engineers' impending study of hurricanes is partly result of long demands by Gulf Coast operators, both on shore and off shore. Oil industry has long pointed out need for more radar, weather ship in Gulf. Engineers will start on East Coast.

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Independent gas producers' chances of escaping shackles of FPC regulation will be jeopardized by high-pressure drive upon Senators up for election, especially those in consumer states. Opponents of legislation will also attempt to amend bill in Senate, thus forcing it back into House, where it might be beaten on next ballot. First time it squeaked through by only six votes.

Encouraging aspect of present situation is that nation's press is not fighting it. Kerr Bill of 1950 was literally drowned in printer's ink.

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Trend for refineries is towards total purchased electric power, when reliable source is available. New refineries, with coking facilities, have added incentive to make outside purchases because they can frequently make deals with their coke. New refinery being built by Tide Water in Delaware is example of such a deal.

-•-

CIO oil union is employing reverse, hat-in-hand technique in impending campaign to organize professional and technical people. Union has always approached each new unorganized element with confidence that it is needed and with neatly packaged sales pitch. But this time President Jack Knight is acting like a man whose inferiority complex is showing. Committee named to study problem of organizing

A Quick Look at the Industry (continued)

professional and technical groups will "throw away the book . . . ," he said, "as regards to our past ideas and practices in union organization. Our purpose is to determine if either or both these groups desire organization of any sort within the near future; if so, what sort of organization they desire, and what sort of contracts they want, giving what sort of protection."

Meanwhile, union was grasping for another plum with aggressiveness more in keeping with its apparent determination to be one of most militant units in impending merger of all CIO and AFL units. To AFL chemical workers meeting in St. Louis, Knight's OCAW proposed merger talks preceding wedding of big unions. OCAW has more than 175,000 members, AFL 69,500.

-•-

Things are looking up for jet fuels. Capital Airlines is tremendously pleased with public acceptance of its first turbo-prop flights. Load factors rose 80 percent after inauguration in July. Capital believes that sustaining of these high load factors means public is attracted by lack of vibration and noise exclusive with turbine powered planes, rather than just novelty of jet flight.

-•-

Industry is not giving up idea that some atomic attack protection is possible, though word from some government quarters is that present H_2 bombs are all-powerful. Question is not "whether or not" but actually how much money should be spent for how much protection. However, it is still true that attempts to provide protection for all of country's industrial establishments is far too costly to be undertaken.

-•-

Texas-Louisiana tidelands operations must now share interest with California, where marine areas were opened when governor signed Tidelands Act. State Lands Commission quickly authorized staff to advertise for bids on offshore parcel west of Newport Beach, which is being drained by nearby on-shore operations.

Development of new area will be comparatively slow procedure because of greater water depths. California Standard will pay $5 million for drilling barge, whereas CATC group (Continental, Atlantic, Tide Water, Cities Service) paid only $1.5 million for self-contained platform that got an oil well in 97 feet of water recently off Louisiana. California Standard barge will be able to drill in 100-150 feet of water.

-•-

Heightened efficiency is slow-but-sure process of minimizing air pollution. Already successfully employed on West Coast is an oxidation promoting catalyst which attains complete combustion. This eliminates many objectionable exhaust constituents while simultaneously increasing potential heat recovery.

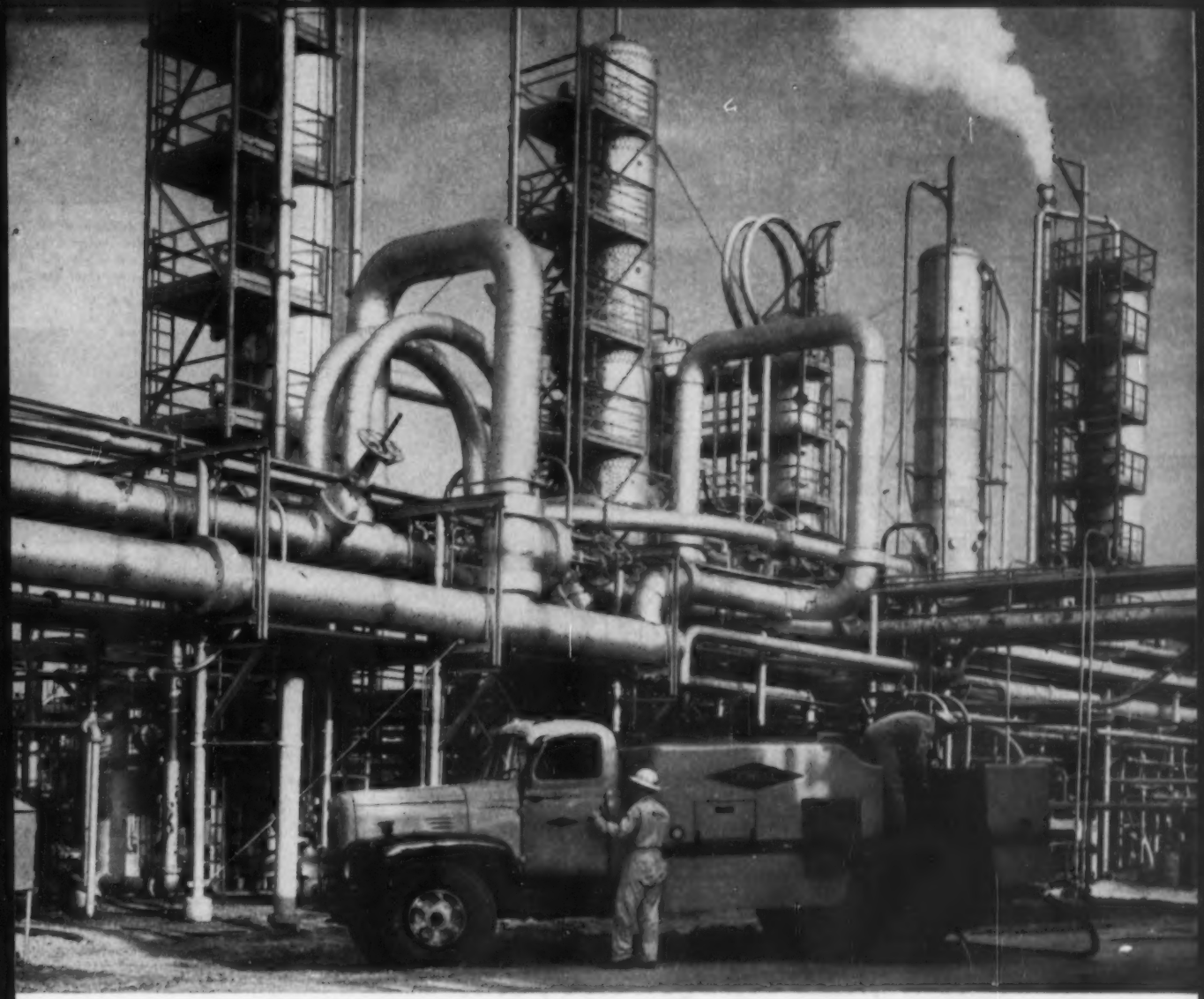
Beyond blueprint stage is idea of equipping autos with valves that will shut off flow of raw gasoline through carburetor and engine when foot accelerator is released. Device is primarily intended to reduce vapors of partly combusted fuel exhausted by decelerating engines, but may also result in increased gasoline mileage.

-•-

Guaranteed annual wage plan could cost as much as 66 percent of payroll. This is finding in study at Northwestern University. Actual employment records of 31 production plans for last ten years were used.

-•-

Refining industry profits for first quarter were $756 million before taxes, as compared with $735 million for the same period last year. FTC figures show $575-million net for first quarter, compared with $543 million for 1954 period.



SIX DAYS OF DOWNTIME SAVED

Refinery tower cleaned chemically by Dowell in only eight hours . . . a six-day saving over mechanical methods!

A refinery operator had to shut down his H_2S stripper bubble cap tower every two months to remove an oily carbonate scale. Each shutdown took seven days, because of the mechanical cleaning methods used, and even then the tower was not thoroughly cleaned.

Dowell engineers were asked to tackle the problem. They cleaned the tower in just eight hours, using chemical solvents. Visual inspection showed the tower to be free of scale with all loose deposits washed from the caps and trays. The operator of this refinery was so impressed that he adopted a regular schedule of Dowell chemical cleaning.

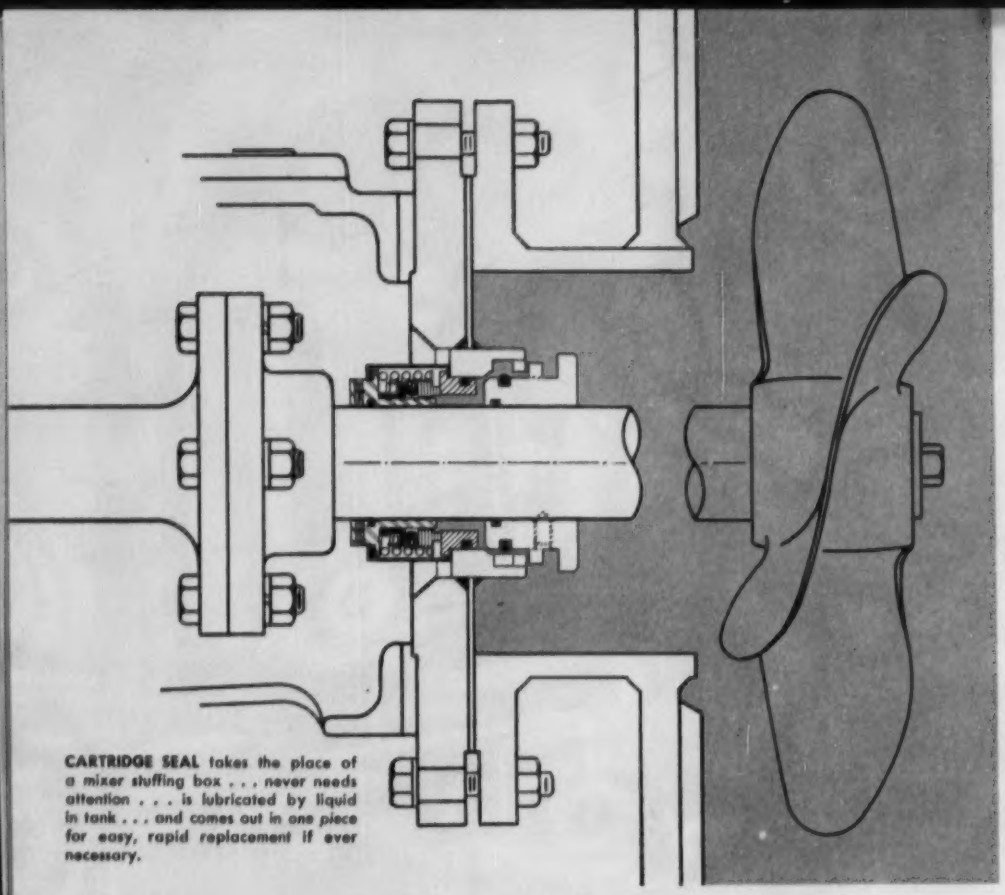
Dowell chemical cleaning methods are designed to reduce costly downtime, because solvents are introduced through regular connections, keeping dismantling at a minimum. Liquid solvents can go wherever gases or condensates flow —to clean angles, bends and other irregular surfaces inaccessible to mechanical methods.

You can help to maintain maximum operating efficiency in your plant by arranging for a regular program of Dowell chemical cleaning. For full information, call your nearest Dowell office, or write Dowell Incorporated, Tulsa 1, Oklahoma, Department I-31.

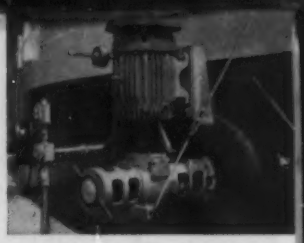
chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

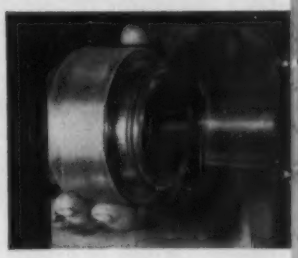


CARTRIDGE SEAL takes the place of a mixer stuffing box . . . never needs attention . . . is lubricated by liquid in tank . . . and comes out in one piece for easy, rapid replacement if ever necessary.



YOU HARDLY EVER need to change a LIGHTNIN Seal. But if you do, it's simple—even with the tank full. Mixer remains on the tank . . .

MIXER SHUTOFF closes like a valve to keep liquid in the tank while seal is being changed. No need to drain the tank.



CARTRIDGE SEAL slides off shaft, which uncouples to permit removal. New seal cartridge goes in its place. Taper on shaft insures correct alignment when recoupling.

Mix fluids in big tanks
at lower cost than ever before
with new quick-change rotary seal

What do you spend yearly to maintain the stuffing boxes on your side entering mixers?

That's a rough measure of what you can *save* by using LIGHTNIN Mixers equipped with new LIGHTNIN cartridge-type rotary mechanical seals.

Here's why you can begin right now to revolutionize your maintenance picture with this amazing new mixer seal:

1. You eliminate "nursing" and periodic repacking of mixer stuffing boxes. The LIGHTNIN Seal gives leakproof operation—for *years,* under most conditions—*without attention of any kind.*
2. *You can replace* a LIGHTNIN Seal whenever necessary—*in minutes.* Without draining the tank. Without dismantling or demounting the mixer. And *without special skill.*

You can get LIGHTNIN Seals now on all LIGHTNIN Mixers. You can get quick delivery from stock, any time, on a wide range of seal types, in materials to suit your conditions.

Already, oil companies using LIGHTNIN Seals report maintenance savings running into many thousands of dollars yearly.

Your LIGHTNIN Mixer representative can give you the full story—show you how much *you* can save. Call him today. You'll find his name in your copy of Refinery Catalog. Or get the facts by mail: Send the coupon for 8-page, fully illustrated Bulletin B-111.

Get the cost-cutting facts now... New 8-page Bulletin B-111 shows how you get maintenance-free sealing that really slashes fluid mixing cost to a new low. Send also for LIGHTNIN Mixer catalogs listed here. Free—no obligation. Just check data you want, tear out and mail to us today with your name and company address.

- ☐ B-111 LIGHTNIN Rotary Mechanical Seals
- ☐ DH-50 and DH-51 Laboratory Mixers
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- ☐ B-104 Side Entering Mixers
- ☐ B-107 Mixing Data Sheet
- ☐ B-108 Portable Mixers (electric and air driven)
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MIXING EQUIPMENT Co., Inc., 164-j Mt. Read Blvd., Rochester 11, N. Y.
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MIXCO fluid mixing specialists

Running a 25-Year-Old Process?

PARDON US for being nostalgic but when September rolls around each year, we count up the years that we've published our special Process Issue. We calculated this issue is our eighteenth, though it was actually born in 1932 (we had to skip a few years during the war because of national security). We are indebted to Standard Oil Company (Indiana) for reminding us of another birthday—a process that is now 25 years old.

And indeed it is a rare process in the ever-advancing oil industry that can observe its twenty-fifth anniversary "on stream" and be more important than ever.

The process is "delayed coking." It was developed by Standard Oil Company (Indiana) scientists for heavy residual oils and first put into commercial operation in mid-August of 1930.

The process still accounts for nearly three-fourths of the nation's oil coking capacity.

Admittedly, the process got a few breaks. It was just what the doctor (of science) ordered when the diesel locomotive came along and put the oil-burning steam locomotive out of business. It also turned out to be the process needed when gasoline octane numbers began jumping and giant catalytic cracking units began calling for feed.

In addition to several delayed coking units built recently by various refiners, American Oil Company has announced beginning of construction of a delayed coker at its new refinery near Yorktown, Va. Amoco is an eastern subsidiary of Standard Oil Company (Indiana).

Dr. Robert E. Wilson, now chairman of the board and chief executive of Standard Oil, was the inventor of delayed coking. He had joined the company in 1922 as assistant director of research. He and his fellow scientists decided that the traditional shell-still coking process must go. It used too much fuel; it ran up big repair bills; and removing the coke from the stills was a hot and dirty job for the workmen.

The patent for the delayed coking process—one of more than 90 patents issued to Dr. Wilson—was filed Decemebr 31, 1928. He became assistant to the vice president in charge of manufacturing in 1929, and was made director and vice president in charge of research and development in 1931. He has been board chairman since 1945.

Several others who worked on the development of the commercial process with Dr. Wilson are still with Standard Oil. They literally sat up nights with the first 450 barrels-a-day test unit.

They include: Dr. W. H. Bahlke, research coordinator at the Whiting Research Laboratory; F. V. Grimm, superintendent of the heavy oils division at the Whiting refinery; W. B. Mathews, coordinator of engineering in the general office of the manufacturing department at Chicago.

Also H. B. Schnetzler, general superintendent of the company's Neodesha, Kan., refinery; Dr. Ernest W. Thiele, associate director of research stationed at the Whiting Research Laboratory; George W. Watts, director of engineering and engineering research, and Dr. R. R. Wilson, superintendent of the asphalt division at the Whiting refinery.

The story of the development runs briefly like this: In the latter part of 1926, a large surplus of heavy reduced crude oil was about to develop at Whiting. Good business required finding a way to turn it into more usable—more salable—material.

Coking had been an important process in petroleum refining for a number of years. Gas oil, suitable for cracking into higher-octane gasoline, was produced as the coke formed. A higher gasoline yield from a barrel of crude oil was the result.

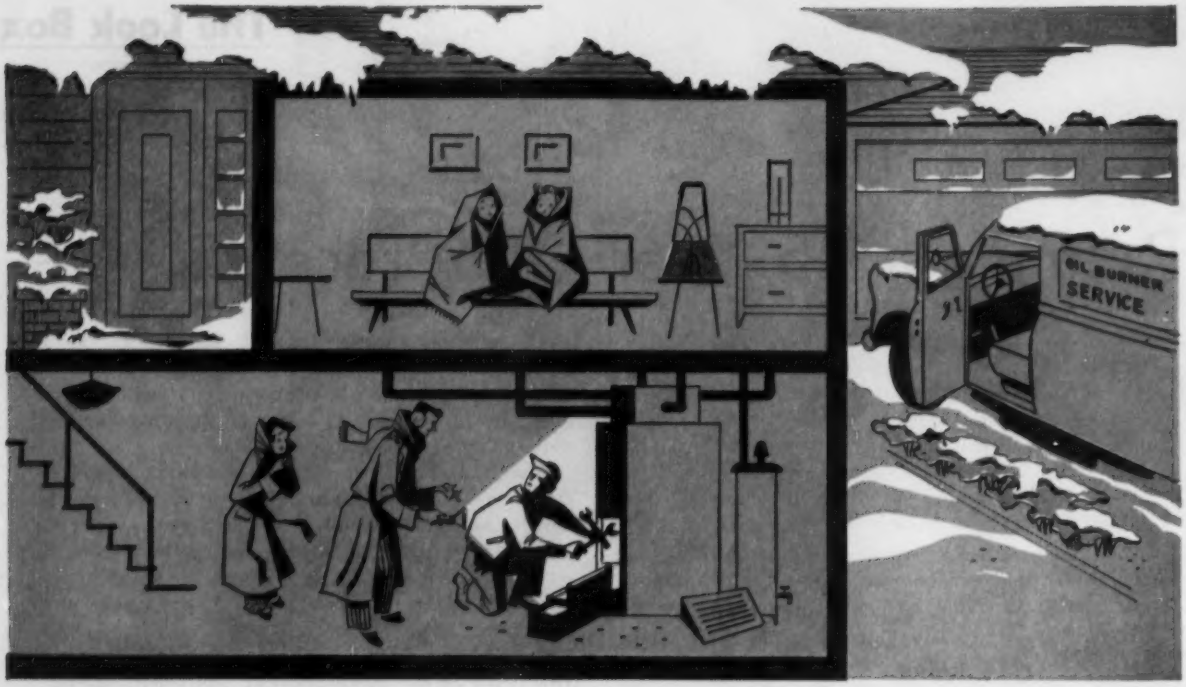
However, the shell stills of that day glowed on the bottom at a red heat during the last part of the run of a batch of coke and were difficult to control. After the volatile material was driven off, the coke was left hard and dry—and hot. Before the still could be used again, men had to go inside the shell with pickaxes and hack out the coke.

Dr. Wilson and others got together and said this was no way to do business. "Let's find an easier way to do it," they agreed. They considered at least 20 different possible ways and tried out many of them in the laboratory. However, the delayed coking idea was developed largely on the basis of theory, and had to be tested on a fairly large scale.

Calculations indicated that the application of sufficient heat would coke residual fuel oil. The question to be settled was whether enough heat could be introduced without coking in the heater tubes. Accordingly, work was immediately started on a semi-works unit with a design capacity of twenty barrels an hour but with only a single coke drum. Much of the equipment for this unit was secondhand. The Burton cracking stills—then just going out of use—provided condensers, product tanks, a coke drum, and even a furnace shell.

Only one or two runs of the semi-works plant were required to indicate that the process was very promising.

Instead of coking batch by batch, the delayed coking process also made it possible to operate continuously. The new process—now 25 years in operation—proved



Oil burner ignition failures can be curbed with this ASHLESS heating oil additive

YOU CAN now use a *single additive* to do *two important jobs.*

As a stabilizer and dispersant, Du Pont Fuel Oil Additive No. 2 does a highly efficient job of preventing sludge formations that cause filter fouling and nozzle plugging.

IN ADDITION, it offers an important plus value by minimizing ignition failures. How?

Being a nonmetallic *ashless* additive, it does not leave a metallic ash deposit which can foul the operation of the electrical system. Thus, it helps to eliminate many of the service calls that cost your distributors time and money . . . and even loss of business through customer dissatisfaction.

Many other advantages

Added to freshly prepared stocks at the refinery, FOA-2 retards the formation of insoluble residues during storage . . . keeps oil free flowing and clean burning. Too, it reduces the particle size of any residues that are formed . . . helps clean out sludge deposits that clog burner filters, screens and nozzles.

Holds customers

Du Pont FOA-2 can help you stimulate consumer preference for oil heat. It reduces need for service—helps provide clean, economical heat. It helps your distributors curb costly, sludge-caused service calls. And it has no harmful side effects.

Refining flexibility

With this stabilizer-dispersant you can blend cat-cracked and straight-run products to gain manufacturing flexibility for varying seasonal demands. You can also use it to upgrade stocks for increase of yield of domestic heating oils. In this way, you can release straight-run stocks for premium diesel fuel or catalytic-cracking charge stock. FOA-2 is effective in diesel fuels, too, for relieving filter-plugging and injector-sticking problems.

Because it is effective in small concentrations, FOA-2 is economical. To find out how much it can do for you and exactly how little it costs, contact your Du Pont Petroleum Chemicals Division representative or regional office.

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to be easier on workmen, made increased production possible at lower cost, and brought other advantages as well.

It is a pity that during the 25th anniversary of delayed coking Indiana should suffer the recent loss at Whiting; but this untimely accident takes nothing away from the brilliance of this company's achievements with delayed coking.

PETROLEUM REFINER wishes to congratulate Standard of Indiana on the twenty-fifth birthday of delayed coking and at the same time thank all companies for their contributions to our annual September Process Issue.

Tom Ponder Joins PR Staff

PETROLEUM REFINER is pleased to announce that Tom Ponder, an engineer-writer with wide experience in the field, joined its staff on September 1 as Petrochemicals Editor.

Ponder, a graduate of the University of Arkansas (B.S. in Chemical Engineering, 1948) is not a newcomer to the ranks of Gulf Publishing Company, he having been engaged at one time in the company's market research activities. Since then he has been with The Lummus Company where he has been a project engineer in charge of project development and estimating. His work there, while dealing chiefly with petrochemical plants, has also included project construction and planning and scheduling, fabricator quotation evaluation and equipment selection and application, plant design and layout, preparation of mechanical specifications, etc. He was assistant project engineer on both Shell Chemical Company's epon resin and bis-phenol plants. Before, he had served Foster Wheeler Corporation in project engineering for Dow Chemical's ethylene plant, Shell Oil's aromatics concentration unit, Deere & Company's ammonia plant and Humble Oil & Refining Company's distillation unit and hydroforming unit at Baytown. From 1948-51 he was a process and project engineer for Columbia-Southern Corporation.

Ponder will succeed Don Rawlings who has resigned to join Howe-Baker Corporation.

"A studious sort of person who is precise to the last detail, Tom is a fine addition to our staff," Publisher R. L. Dudley declared. "He has a good scientific mind, sufficiently curious to make him an alert editorial man. From his wide circle of friends in the industry we bespeak in his behalf the fullest cooperation. We can promise in return that industry will always find Tom most helpful in his new capacity."

Your Part In Oil's Own Week

IN THE MONTH ahead, the refining group will be called upon to join spokesmen for other branches of the oil business in promoting Oil Progress Week, October 9-15. Committees will have to be manned, talks prepared, a big one, and some people may wonder if it is getting exhibits scheduled, appointments made. The job will be them anywhere. It is, according to a recent poll of Sun Oil Company employes.

The survey revealed that 90 percent of the employes interviewed thought Oil Progress Week was worthwhile from their own point of view—that they learned a great deal about their industry and company, that it was "good public relations" for the industry, and that it contributed to their job security. In reply to one question, 80 percent of those interviewed said they thought Oil Progress Week was "worth all the time, money and effort that went into it."

Oil Progress Week is a device which offers opportunity for widespread community level participation—there is something for everyone to do. If you can not make a speech, you can arrange a film showing for your church club, or arrange for an Oil Progres; Week placard in your grocer's window. The oil refinery worker, as well as the big company executive, can play a part. And the role he plays is as much for his own sake as for his company or the industry.

Heating Oils Near Excess

RECENT high level refining operations pushed distillate fuel oil supplies toward undesirable quantities, and if allowed to continue heating oil could become burdensome before winter begins.

During July, U. S. refineries set a new all-time record by processing an average of 7,599,000 barrels of crude per day. That was 90,000 barrels a day greater than June's rate, and 50,000 more than the previous monthly peak hit in February.

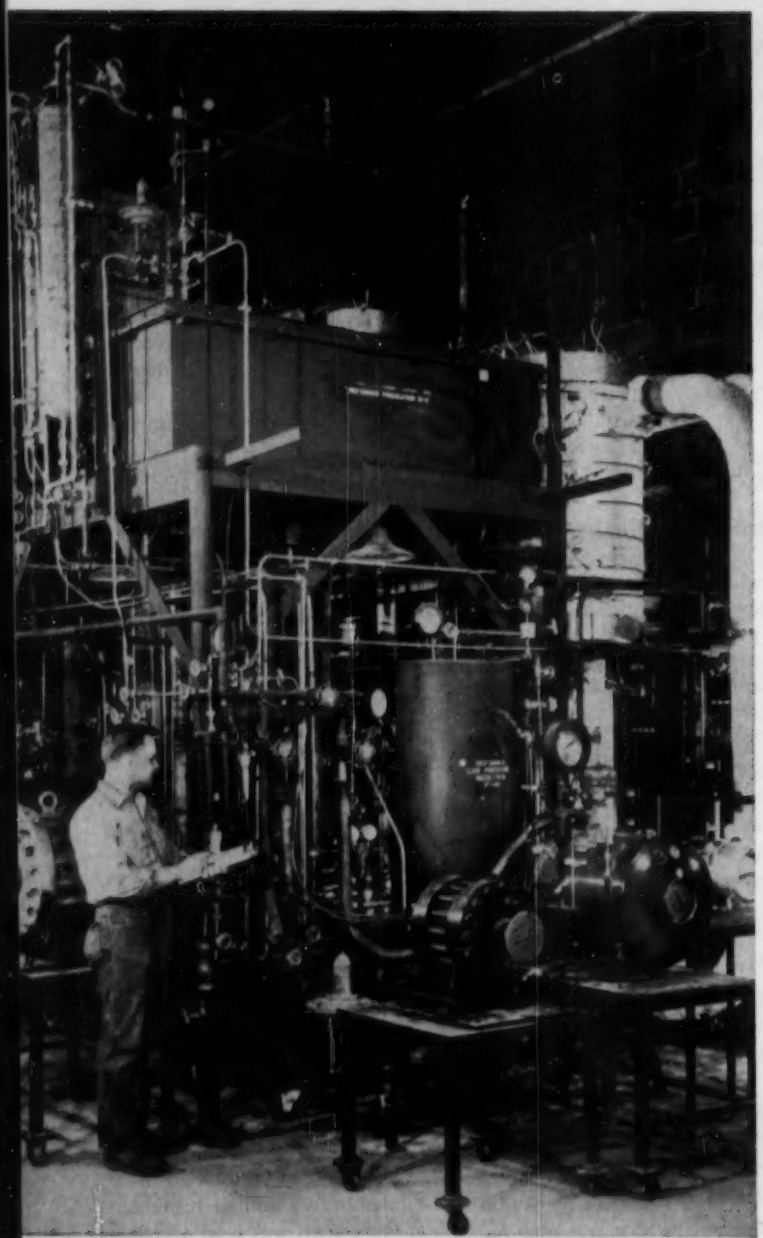
Distillate stocks reached a seasonal high of just under 125 million barrels according to the latest inventory of August 19. That level was not reached last year until a month later, so there is every likelihood of bulging tanks by November.

Present heating oil inventories are 13½ million barrels greater than they were at the same time in 1954, and just 14 million short of the all-time peak. Since the end of March, 62⅓ million barrels have been added to stocks, while 50 million were tanked in the same period of last year.

Recent weeks have seen some decline in refinery thruput rates, and the resulting reduction in distillate production was encouraging.

High demand has kept record gasoline output from creating excessive stock accumulations. Motor fuel inventories on August 19 totaled 155½ million barrels, which was only ½ million more than was held a year earlier. If supplies can be further lowered until the end of September, that product can enter the build-up season in good shape.

New catalytic reformates road-tested by Ethyl Research



Samples for analysis at Ethyl Research Laboratories are taken directly from the pilot plant of the reformate process developer.

In choosing one of the important new reforming processes, or in planning the over-all refinery operations once the plant is on stream, it is vital to know how the reformate will behave in the gasoline to be marketed.

That's where we can help you. Ethyl's Refinery Technology group in Detroit, working closely with the developers of these new processes, has prepared several reports on road antiknock behavior of reformates. And more reports are in process.

Each of these Ethyl reports is based on evaluation of reformate samples from commercial units or from the developer's pilot plant. We blend the new reformates with typical refinery base stocks—straight-run, catalytically cracked, and thermally cracked naphthas—to produce typical gasolines. "Ethyl" antiknock compound is then added, and the gasolines are road-tested on chassis dynamometers in our controlled-weather rooms.

Finally, all the information is collected, evaluated and submitted for approval to the developer of the process.

Reporting to the industry on the behavior of catalytic reformates is another example of how Ethyl is helping serve your needs.

If you have a problem in octane improvement, get in touch with your local Ethyl Refinery Technologist. He'll be glad to work with you.

ETHYL CORPORATION
Research Laboratories

1600 West Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

Final report on a new reformate process is presented to customer by Ethyl Fuel Technologist Alon Cole. This and other Ethyl Research reports are available to you through the Ethyl Refinery Technologist in your area.

Reformates are blended with various runs of gasoline and tested by Ethyl technicians.

Road testing is performed with various gasoline stocks in Ethyl's highly instrumented controlled-weather rooms.

Are you paying too much for your electricity?

Are you getting the most for money expended on purchased power?

How To Stretch Your Power Dollar

Luther W. Davis
Power Cost Consultant
Dallas

POWER CONSUMERS pay out millions of dollars needlessly each year.

Are you paying too much for your electricity? Are you getting the most for money expended on purchased power?

The oil industry, by and large, does a topnotch job of turning out goods and services. Why, when the same management skills are involved, is the power service function so often neglected? The answer seems to lie in a lack of awareness of the profit potentials of the power services.

It would be impossible to discuss even a fraction of the many ways of reducing power costs here, so only some of the basic principles will be touched.

What happens when sound managerial principles and wise power-purchasing policies are put to work? Examples of the resulting benefits are legion and actual cases could be cited endlessly.

Here are typical cases, selected because they show, in various ways, the application of some of the principles to be discussed. The cases are real, *and so are the profits.*

- Oil company being billed on a special electric rate negotiated several years ago. By changing to one of three standard wholesale rates used generally elsewhere by the utility, the company had a reduction of 12 percent in power costs.
- Oil company's entire power requirements metered and billed on generally applicable rate schedule. Investigation revealed that 75 percent of the consumption was in equipment qualifying for a lower rate classification. Therefore, services were separated and metered and billed at two points for a recurring annual reduction of about 8 percent in power costs.
- Oil consumer billed on a general power contract rate and the net cost was less than 1 cent per KWH. It was discovered that one of the contract rider provisions was not being applied correctly. The proper application of all provisions of the rate, approved by the State Commission, resulted in a reduction of a monthly power bill from $845.11 to $776.09.
- Oil company owned transformer and was being billed on a rate structure created especially for oil field usage. By changing to a rate available to any commercial or industrial consumer, saves about $170 a year and the utility furnishes the transformer. Company salvaged two poles and a small transformer, without any wiring changes or investment.
- Local manager of utility declined to apply lower electric rate applied for, but was glad to apply it when he learned his company was using this same rate in another area served by them. The result—a saving of $5000 a year for the oil company.

Art of Purchasing. In two senses, the purchase of electricity for indus-

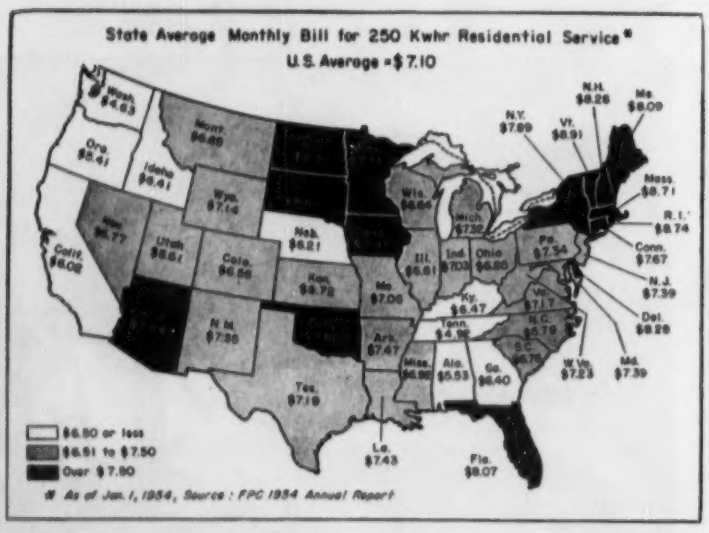


FIGURE 1—Not generally known, rates vary considerably between two different consumers on the same utility, for exactly the same number of KWH used.

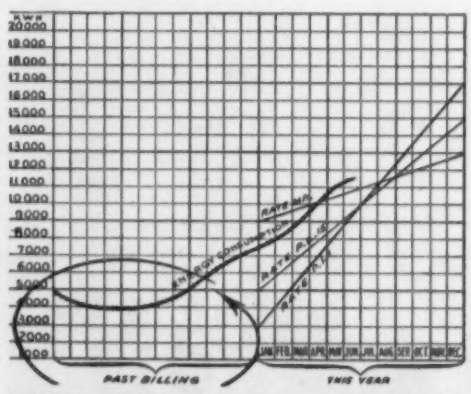


FIGURE 2—Electric power rates cross at some point when other rates may be used to an advantage. Have your monthly utility bills analyzed to protect you against irregularities.

trial use is an art. One side of the problem that has been long and widely considered by many engineers is expressed in the question, "Shall we buy or make?" Assuming the correct answer to be "buy," as is often the case, the second problem is "How shall we buy?"

To many executives, this second question will seem strange. With the idea that rate schedules are fixed in most localities, they see so "art" in buying, beyond signing the contract, making the connections, exercising reasonable care in the use of current —and, paying the bills.

And, in so over-simplifying the problem, they repeat the mistake that in the national aggregate costs industry millions of dollars annually. To avoid this error and salvage these losses, management must learn to recognize that the buying of electricity is an art demanding skill equal to the best applied in power generation.

In addressing this report primarily to top executives, who are not assumed to have special knowledge of power-service technology, we speak also to the engineers who are familiar with such utility rate "factors" as power factor, load factor, responsibility load factor, capacity and usage factor, utilization factor, demand factor, diversity factor, coincidence factor, operation factor, etc., all of which have a direct bearing on the lowest net power costs available.

Profit-opportunity in the power services is often neglected because management does not realize that the responsibility is theirs to qualify for and request the power company to bill them on the rate of their selection. One power company goes so far as to point out in their standard contract:

> "The customer should analyze and study his operations from time to time for the purpose of determining the desirability of changing from one available rate to another. The company does not assume responsibility."

The reason for this is expressed this way by one utility company:

> "We cannot assume the responsibility of checking all bills at all times to assure the best possible rate application. To do so would greatly increase our billing costs and consequent cost of service."

It has been held that it would not be reasonable to require the utility companies to check up at frequent intervals to determine whether the character and extent of the customer's service had so changed as to entitle him to a more favorable schedule—or whether new rates had been created which would reduce the customer's costs.

The utility companies desire to give the best possible service. However, rules made (and in the rate schedules) to comply with the reasonable demands of one diligent consumer, may be, and often are, overlooked when the next consumer comes along. The utility employe fixing your rate does the best he can, and it is your duty to see that his attention is called to any rate that he has honestly overlooked . . . and to keep everlastingly on the job in the future, to detect any new way to reduce your costs.

Most of the utility companies have designed rate schedules which give their customers the benefit of lower rates for special or larger uses of the service. Many state public service commissions do not permit special contract rates, but insist that even a special agreement with an individual customer, covering special conditions, must be filed as a rate schedule without mentioning the name of the customer, so that any other customer who meets the same conditions at a later date is automatically entitled to service under the same schedule, if requested in the proper manner. Many of the rate schedules are known as optional rates. The customer can take service on whatever basis under the established schedule he can figure will produce the lowest bill for his particular use or business, when he discovers and applies for it properly.

Experts' Job. Utility rate schedules and contracts are complicated. To describe the conditions under which a utility will render service, a specialized terminology has been employed. These specialized terms are not defined in a dictionary or glossary to which all utilities subscribe. In many cases, the rate schedules contain technical expressions without defining their significance in detail.

> ". . . whether defined or not, these technical terms may be used with quite distinct and contradicting significances by different utilities," the Federal Power Commission says.

These variations are due generally to differences in points of view, in emphasis, and in interpretation rather than to basic differences.

The Supreme Court of the U. S., in a utility case, said:

> "Use of that term in a context of generality wears an appearance of precision which proves illusory when exact application becomes necessary. Relevant authorities and considerations are numerous and equivocal, *and different plausible definitions result from a mere shift of emphasis.*"

All of which probably prompted one State Public Service Commission to say:

> ". . . We could write a book on these contracts and probably would not cover all of the points that will come up in the next one. All these matters should be handled by competent experts representing the parties to the contract."

Public Service Corporations, such as electric power companies, by reason of the extraordinary privileges accorded them, which include the right of eminent domain, the power to exterminate all competition, and the right to monopolize a business of vital import to the public, are quasi-public corporations engaged in a business affected with the public interest.

It is a universal rule that a public utility cannot discriminate in its rates or charges between consumers similarly situated. How does this work out in actual practice?

(Concluded on next page)

Meet the Author

LUTHER W. DAVIS, a native of Texas, has spent his entire professional life working for the consumer interest in matters pertaining to utility costs. Even before receiving his license to practice law in 1937, he was utilizing his rate engineering experience in this work. Working from Dallas, he has been a power cost consultant for the consumer throughout the U. S., Hawaii and parts of Canada with "Rateonics" (rate engineering).

Microfilmed Data Offer Easy Way Out

Given this equipment with simple instruction, data collectors have a method that is rapid, accurate, inexpensive, convenient.

Carl Cline and Carroll F. Knutson,
Continental Oil Company,
Ponca City, Oklahoma

A RAPID, ACCURATE, inexpensive, and convenient method of collecting data has been devised and proved through use—on-the-spot microfilming.[1]

The equipment can be carried easily in a brief case (See Figure 1):

• A 35 millimeter camera and accessories. The single lens reflex type is the most convenient for this work, but almost any type can be used satisfactorily. The camera lens is important. A good lens with a maximum aperture between f/3.5 and f/4.5 is adequate for taking illustrative pictures under most lighting conditions, and provides good resolving power for microfilming.

Unless lens resolving power information is available, the lens selected should be tested by a lens specialist before purchase, or checked by the buyer[2,3] if a specialist is not available. If a well corrected lens with a resolving power in the order of 90 lines per millimeter cannot be obtained with the camera selected, such lenses can be obtained from optical companies.

• Light meter. The one purchased should be of the photo-electric cell variety with an incident light attachment. The incident light readings may be used directly to calculate exposure times for microfilming.

• Tripod and head. This equipment should occupy a small space when telescoped for storage (15 inches or less) and should form a stable camera base. The tripod should have a positive lock and should tilt about 90 degrees from horizontal and rotate 360 degrees.

FIGURE 1—The camera is set up in copying position. A. Camera mounted on tripod; B. light meter; C. film.

Film cost and operational speed—Cost of all 35-mm. film is low (see Table 1, Page 362). Good microfilm, as well as illustrative pictures, can be made with standard fine grain negative materials.

Approximate exposure time for the various types of film, with the lens set at f/8 and with average office lighting, also are listed in the table. For very light blue ink or faint pencil writing, the exposure should be decreased.

Speed of operations is an important factor. Two 8½-by-11-inch pages can be photographed in each exposure. Advancing the film and winding the shutter requires from two to five seconds. Placing data to be recorded under the camera is the most time-consuming phase of microfilming.

If the data are bound or in a loose-leaf book and in correct chronological

See Microfilm, page 362

Stretch Power Dollar

(Continued from preceding page)

It is generally known that the price of electricity varies widely in different localities for exactly the same number of KWH used. But, it is not generally known that rates vary considerably between two different consumers on the *same utility*, for exactly the same number of KWH used.

For example, in one oil center four different customers' net power costs can be: less than 1 cent per KWH, 1.1 cents per KWH, 1.3 cents per KWH, 1.4 cents per KWH—*for exactly the same number of units of electricity used.*

This is not an isolated example of the difference in electric power costs for exactly the same KWH used. Rate Series No. 4 of the Federal Power Commission has examples from every area in the U. S., showing the difference in costs for the same amount of electricity from the same utility on different rate schedules available.

Analyzing Your Case. Are you paying more than you should for power? How can you find out?

The first thing, of course, is to find out exactly what you are spending at the present time. Then analyze all power rates over the entire system, including special rates, to see how the lowest purchase cost may be achieved and to see what it will be. Then continue the rate analysis and keep everlastingly at those elements of operation that neglected, boost the cost of purchased power.

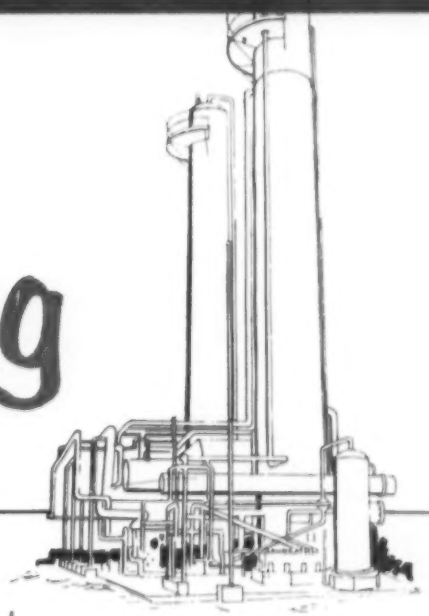
In making a rate analysis, it is often not wise to depend entirely upon information that can be secured locally. After exhausting every available means to get lower costs, if you have any reason to believe you are paying excessive power costs, there are independent power cost specialists you can call on for needed advice. ##

PETROLEUM
REFINER

1955 Process Issue

3 quality chemicals for superior

Gas Scrubbing



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diethanolamine
diethanolamine | diethylene glycol | *for dehydrating natural gas*

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After that the little valve actually *floats on the condensate load*—maintains peak temperatures.

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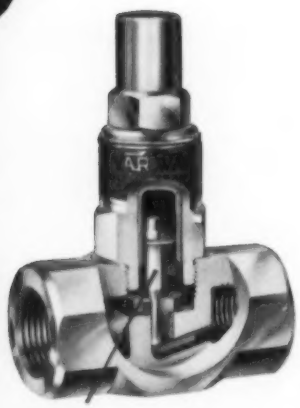


This little valve—only moving part in a YARWAY Impulse Steam Trap—*floats on the condensate load.* It gets equipment hot in a hurry and keeps it hot!

YARWAY
impulse
steam trap

OVER 1,000,000 YARWAY IMPULSE TRAPS SOLD—STOCKED BY 270 CONVENIENT INDUSTRIAL DISTRIBUTORS

They advised: Plans for this special Process Issue were made at a conference in February when the REFINER staff met with these four industry experts: Zane Q. Johnson, Gulf Oil Corp., Port Arthur; V. A. Kalichevsky, Magnolia Petroleum Company, Beaumont; Dr. E. P. King, The Pure Oil Company, Nederland; and E. Clarence Oden, The Chemstrand Corporation, Decatur.*

PROCESS ISSUE '55

THIS 18TH ANNUAL PROCESS ISSUE brings the refiner up-to-date on refining process advances. Last year's issue presented a complete handbook to processes; this year's puts emphasis on detailed analysis of new developments. While new processes have developed rapidly over the past few years, refiners have been anxious to see the results of the first commercial installations of these new processes. For what is happening, take a look at these major trends:

Gasoline Quality: The biggest push is still gasoline quality. Compression ratios for 1955 automobile engines averaged 8:1 (compared to 6.88-1 in 1949) and 1956 models promise to take another step up. Octane levels in some areas are up to 98 Research. Premium now averages 95.8 and regular 88.5.

As was the case last year, catalytic reforming is the most important process in any quality improvement program, but refiners are taking a look at other means: more severe catalytic cracking, new extraction processes, more alkylation, more polymerization and isomerization.

For a most comprehensive look at all octane improvement techniques, we are presenting in this issue a 51-page report on "How to Get Those Top Octanes" (230). This article includes the most authoritative comparison of catalytic reforming processes to date.

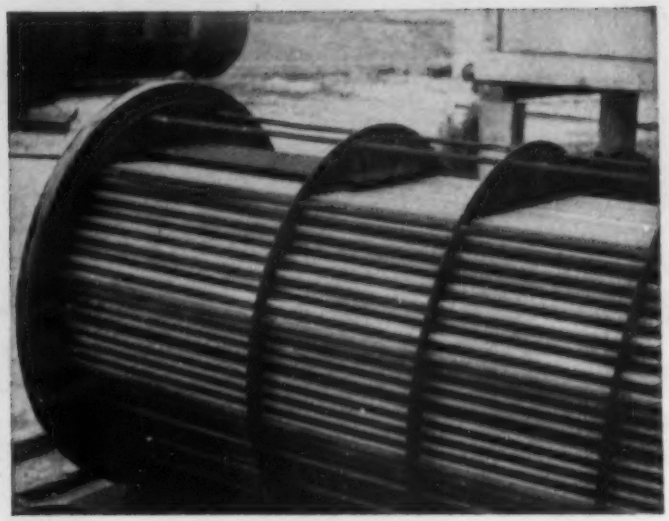
Catalytic Reforming: The refiner now has 13 catalytic reforming processes from which to choose. All are represented by commercial installations except the two latest entries—Rexforming, a modification of Platforming (PR,Apr.,p.116 and this issue) and Iso-Plus, a modification of Houdriforming (PR,Apr.,p.249 and this issue). Both of these already have units under construction. The past year has also seen the appearance of the new Orthoforming Process (p. 164) and the Esso Platinum Process (three units now completed).

Hydrogen: The excess hydrogen from these reformers is occupying the minds of all refiners—will it be used for fuel (as much of it is now), for petrochemicals or for upgrading petroleum products and stocks? Most feel that the excess supply will gradually be taken up by hydrogen treating and finishing processes and that an actual shortage will result. Upgrading products

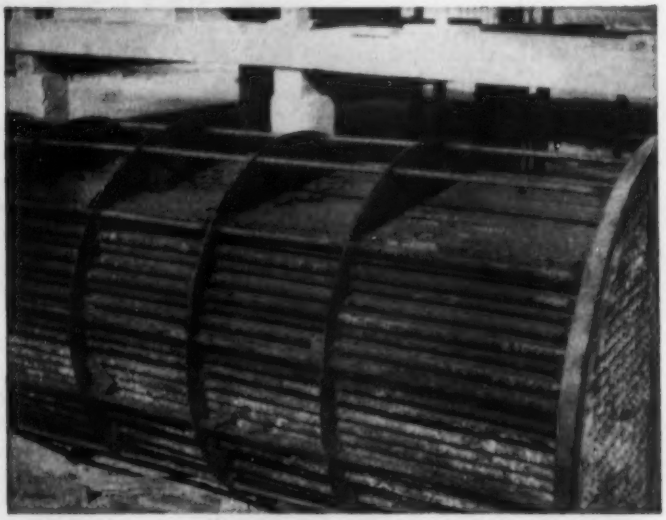
* The attendance by executives, engineers, superindents and other employes of oil and petrochemical companies at these conferences does not constitute an endorsement of Petroleum REFINER over any other one publication. The fact that men of outstanding ability are allowed to attend these planning conferences shows the interest which the oil and petrochemical industry has in sound editorial content planned for the benefit of the industry and those who work in it.

Which bundle do you want to find

at turn-around time?



This?.. Here's what a refiner likes to see when he pulls his bundles at turn-around time. This clean, uncorroded appearance is typical of what can be expected when you use Polyrad.



or this?.. This is an all too common sight at turn-around time. Corroded and fouled bundles such as these call either for costly replacement, repair, or cleaning.

These two bundles from the overhead condensing system of a Gulf Coast refinery tell a story. One is what the refiner likes to find at turn-around time; the other, what he is likely to discover without Polyrad.

More and more refineries have found that when they use Polyrad, the filming amine inhibitor, they can expect to find bundles free of corrosion, ready for immediate return to service. As a result turn-around time no longer need be headache time.

Why not make use of Polyrad's detergency to maintain throughput, increase heat transfer, and cut down time for maintenance?

Stocks of Polyrad are maintained throughout the country. A Hercules technical representative will be glad to discuss its application to your operating conditions.

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NA66-5

has a spiraling effect—one refiner upgrades one product and another refiner upgrades a different one. The net effect is that all have to upgrade all products.

Use of hydrogen for ammonia will represent only a small amount of total reformer hydrogen produced. Capacity to produce ammonia from all hydrogen sources is now greater than demand. Marketing strength is an outstanding requirement for success in ammonia production (PR,June,p.171).

Use of hydrogen as refinery fuel will prove to be only an expedient measure.

The hydrogenation processes date back to 1927 when high-pressure hydrogenation was introduced in the U. S. by Standard Oil Company (New Jersey). Operating data from the first installations of Diesulforming and Shell "Trickle" Hydrodesulfurization appear on pages 158 and 152. Interest in hydrogenation processes was enhanced this year by the announcement of the Gulf HDS Process (PR,May,p.156), which can be used to upgrade the entire crude charge. Though the cost is now too high for existing refineries, it offers possibilities for new refineries operating on high-sulfur crudes.

Alkylation: This is another process which nearly every company is taking a look at. It was important in World War II to get high octane gasoline for aircraft. Now that auto engines are getting up there, it's being considered as one way to balance the motor fuel blend. Alkylate has an intrinsic advantage at the present time since sensitivity is becoming a problem. Direction of cat reformate is toward increased aromatic content which increases sensitivity beyond desirability. Alkylate, on the other hand, can do much to balance this in a gasoline blend.

Phillips announces the new features of its HF Alkylation Process in this issue. Operating data from the first effluent refrigeration sulfuric acid alkylation process are found on p. 126. For the acid disposal problem, take a look at the new Miley Process on p. 138.

Isomerization: If alkylate catches on, there will be some isomerization of butane to make isobutane feedstocks; but it will be limited, since isobutane is usually in sufficient supply within the refinery or it can be bought from natural gasoline plants. Big interest now is in isomerizing C_5 and C_6 fractions at refineries (natural gasoline plants, too). Like alkylation, it's a step in the right direction for a balanced blend of high octanes.

There is hardly a product in the refiner's range which hasn't benefited by some new process this year. For lube oils, see articles in this issue on "Applying RDC to Lube Extraction" and "How the First TCP Unit Operates," (pp. 129 and 206).

Every year sees new developments in treating gasolines and distillates. Check the articles on Ferrocyanide Treating (p.155), Dualayer (p.142), Bender (p.182), and Electrical Precipitation (p.194).

And most of all, do not fail to study the comprehensive monograph "How to Get Those Top Octanes."

George B. Gibbs

PROCESS BOXSCORE

The activity in the refining industry to date may be seen in this tabulation of licensed process units operating and under construction.

Company and Processes	Units Operating	Units Under Construction
AMERICAN DEVELOPMENT CORPORATION		
Electrolytic Mercaptan	3	0
ATLANTIC REFINING COMPANY		
Catforming	17	7
Nitrobenzene Extraction	1	0
BLAW-KNOX COMPANY		
Decarbonizing	1	0
THE BRITISH PETROLEUM CO., LTD.		
Autofining	3	0
CALIFORNIA RESEARCH CORPORATION		
California Polymerization	30	9
Cyclic Absorption Refining	0	0
ESSO RESEARCH AND ENGINEERING COMPANY		
Fluid Catalytic Cracking (Mod. IV)	22	2
Fluid Hydroforming[1]	8	2
Fluid Coking	2	4
Hydrofining	14	2
Platinum Reforming	2	1
FILTROL CORPORATION		
Continuous Contact Filtration	39	1
THE FLUOR CORPORATION, LTD.		
Glycol Amine Gas Treating	28	0
FOSTER WHEELER CORPORATION		
Combination Visbreaking	2	0
Crude Distillation for Maximum Lubes	132	5
Delayed Coking	3	0
THE GIRDLER CORPORATION		
Girbotol	400+	0
GULF OIL CORPORATION		
Polyforming	13	0
HOUDRY PROCESS CORPORATION		
Houdriflow (Including Houdresid)	10	0
Houdriforming (Including Iso-Plus)	6	1

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City_____ Zone____ State_____

PR-9

PROCESS BOXSCORE . . . *Continued*

Company and Processes	Units Operating	Units Under Construction
HOWE-BAKER CORPORATION		
Electrical Desalting	61	6
Electrical Distillate Treating	4	8
HUSKY OIL COMPANY		
Diesulforming	1	1
THE M. W. KELLOGG COMPANY		
Catalytic Alkylation	22	4
Catalytic Polymerization	29	6
Catalytic Desulfurization	1	2
Delayed Coking	14	1
Fixed-Bed Hydroforming	6	0
Fluid Catalytic Cracking (Including Orthoflow)	60	6
Fluid Hydroforming	3	0
Orthoforming	1[2]	0
Phenol Extraction	22	1
Propane Deasphalting	34	3
Propane Dewaxing	13	2
Propane Fractionation	2	0
S B K Catalytic Reforming	1	3
Solvent Decarbonizing	7	1
THE LUMMUS COMPANY		
Combination Cracking	13	0
Continuous Contact Coking	1	0
Delayed Coking	9	1
Doctor Treating	7	0
MAGNOLIA PETROLEUM COMPANY		
Dualayer Fuel Oil Treatment	2	0
Dualayer Gasoline Treatment	0	1
THE MILWHITE COMPANY, INC.		
Duo-Sol	19	0
MINERALS & CHEMICALS CORPORATION OF AMERICA		
Percolation Filtration[3]	50	0
PETRECO DIVISION, PETROLITE CORPORATION		
Electric Desalting	306	21
Electric Distillate Treating	10	10
Electric Lube Oil Treating	5	1
PHILLIPS PETROLEUM COMPANY		
HF Alkylation	2	0
Copper Sweeting	225	0
Cycloversion	32	2
THE PURE OIL COMPANY		
Mercapsol Treating	1	0

Company and Processes	Units Operating	Units Under Construction
SHELL DEVELOPMENT COMPANY		
Butane Vapor Phase Isomerization	9	0
Hydrodesulfurization	2	1
Liquid Phase Isomerization	6	0
Phosphate Desulfurization	44	0
Tannin Solutizer	33	1
SINCLAIR REFINING COMPANY		
Bender	5	1
Sinclair Catalytic Reforming	3	2
SOCONY MOBIL OIL COMPANY, INC.		
Socony Airlift TCC	39	11
Sovaforming	2	5
Thermofor Catalytic Reforming	2	0
Thermofor Continuous Percolation	2	0
STANDARD OIL COMPANY (INDIANA)		
Ultraforming	9	6
STONE & WEBSTER ENGINEERING CORPORATION		
Crude Distillation for Maximum Cracking Feed	5	0
SO_2 Extraction	11	0
STRATFORD ENGINEERING CORPORATION		
Effluent Refrigeration Alkylation	4	3
Sulfuric Acid Alkylation	25	0
TEXACO DEVELOPMENT CORPORATION		
Furfural Extraction of Gas Oils	6	1
Furfural Refining	49	1
Solvent Dewaxing	70	1
Wax Fractionation	31	0
Wax Manufacturing	6	1
TRETOLITE COMPANY DIVISION		
Chemical Desalting	82	9
UNION OIL COMPANY OF CALIFORNIA		
Hyperforming	1	0
Unifining	18	18
UNIVERSAL OIL PRODUCTS COMPANY[4]		
Catalytic Polymerization	133	5
Fluid Catalytic Cracking	50	15
HF Alkylation	7	3
Isomerization	1	0
Platforming	60	38
Thermal Cracking	89	0
Thermal Reforming	14	0
Unisol Mercaptan Extraction	3	0

[1] Some processes are joint developments; therefore, the total number of units may be divided among several companies. Fluid Hydroforming, for example, is a joint development among The M. W. Kellogg Company, Standard Oil Company (Indiana), and Esso Research and Engineering Company and is available through several engineering contracting companies.

[2] This unit was destroyed during an accident occurring on August 27, 1955.

[3] Some of the older processes, such as percolation filtration, are not licensed, so figures are necessarily approximate.

[4] Reported results are unconfirmed.

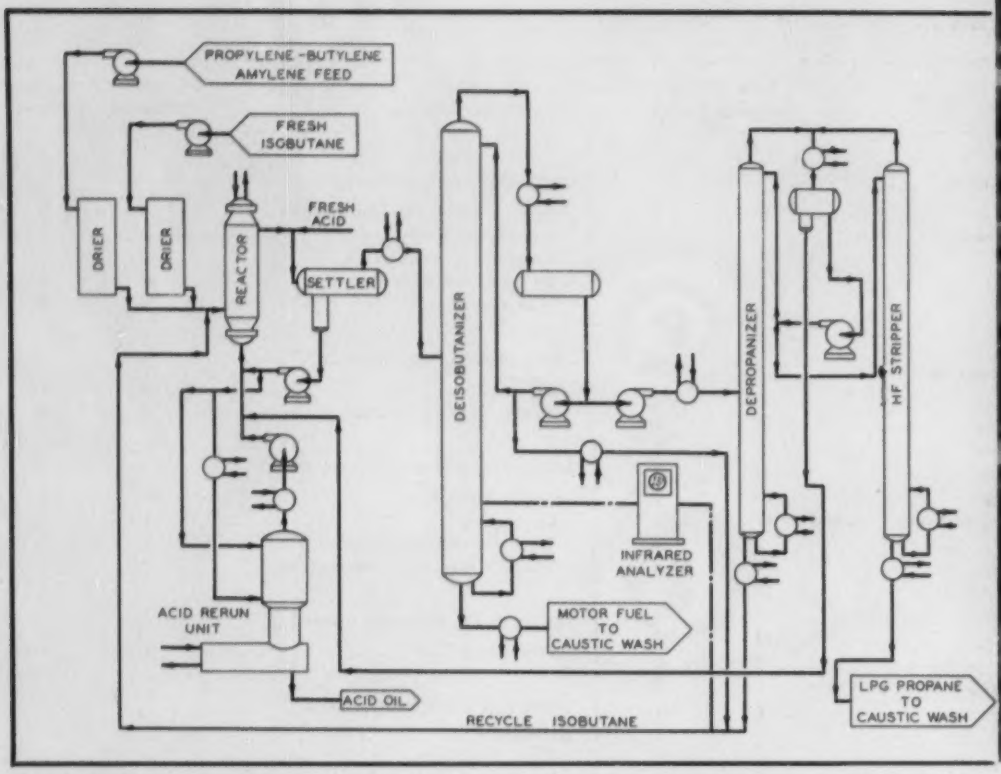
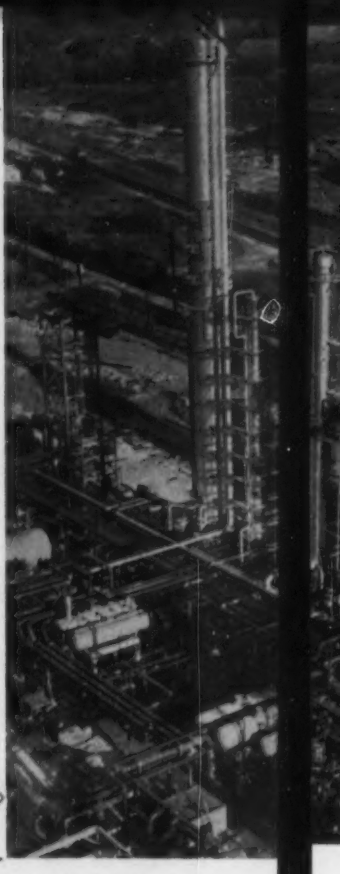


FIGURE 1—HF alkylation process for motor fuel production: Two fractionators, the debutanizer and the alkylate splitter, necessary to manufacture aviation alkylate, are not required here.



Modern HF alkylation unit: Only two men

NEW HF ALKYLATION PROCESS

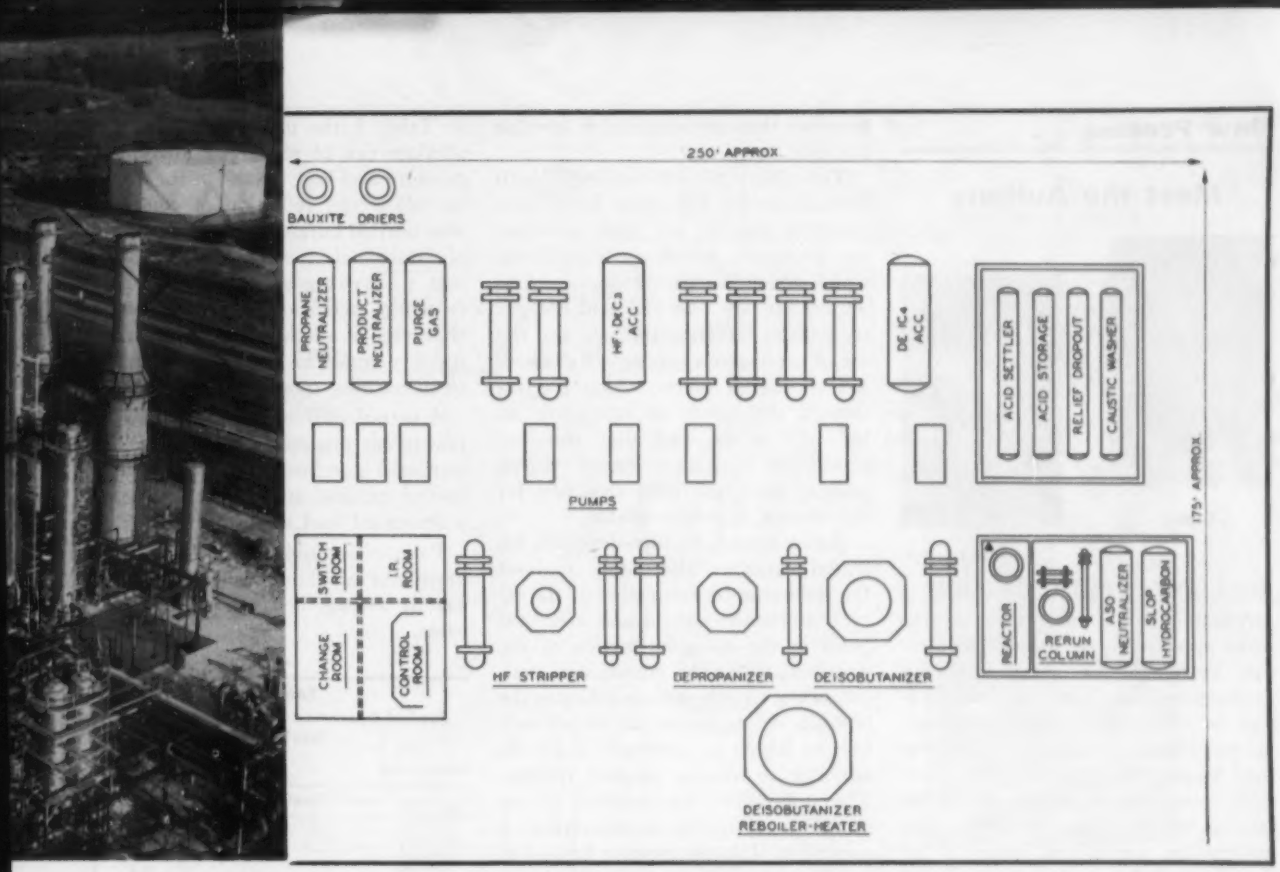
W. D. Peters and C. L. Rogers,
Phillips Petroleum Company, Bartlesville

THE CONTINUOUS alkylation of isobutane with light olefins such as propylene, butylenes, and amylenes, using liquid hydrofluoric acid as a catalyst, is a well established process for the production of high octane blending stock. During World War II, and for several years following, a tremendous quantity of alkylate was produced by this process and utilized entirely in aviation gasoline. Recently, due to the relaxation of government regulations, alkylate has become available for motor fuel blending. HF alkylate is becoming prominent in motor fuel blending plans to answer the demands for higher octane and improved quality. The low vapor pressure of alkylate and its high octane number, coupled with the fact that the process upgrades low value light materials, make HF alkylation extremely attractive.

The essential features of the new Perco HF alkylation motor fuel process may be seen in Figure 1. The extreme simplicity of the process, compared to the early war-time aviation alkylate units, is readily apparent. It should be noted that no intermediate charge pumps, surge tanks, or stripping towers are employed between the outside charge pumps and the deisobutanizer tower. Two fractionators, the debutanizer and the alkylate splitter, necessary to manufacture aviation alkylate, are not required to produce motor fuel.

Liquid feed from storage is taken through bauxite driers into the reactor where it is contacted with liquid HF. The acid enters the reactor through a recycle line from the acid settler. No mechanical agitation is required to complete the reaction. Sufficient mixing is obtained by injecting the hydrocarbon into the acid through a special nozzle. The elimination of the mechanical agitator causes no loss in product quality and results in lower initial investment, lower operating costs, and reduced mechanical maintenance. Without an agitator, the reactor is essentially a carbon steel tube and shell heat exchanger.

The reaction is cooled effectively



per shift are required for operation.

FIGURE 2—HF unit plot plan: Equipment is easily accessible for maintenance and operation.

- **No intermediate pumps, tanks or stripping towers are employed between the outside charge pumps and deisobutanizer.**
- **Infrared analyzer alternately analyzes the isobutane concentration in the recycle and deisobutanizer.**
- **Payouts for 1000-4000 bpd units average 1 to 1½ years.**

by circulating cooling water. No refrigeration is required. No change in alkylate quality has been detected for reactor temperatures between 80 and 100 F., within which limits cooling water is readily available. The acid-hydrocarbon ratio of the reactor feed is not critical and may vary from 0.2:1 to 1:1.

An excess of isobutane is recycled to the reactor to control product quality. Internal isobutane-to-olefin ratios from 2:1 to 20:1 have been used; however, for motor fuel production, the optimum ratio is approximately 6:1.

The use of a direct fired reboiler furnace on the deisobutanizer thermally reduces the fluoride content of the bottoms product to such an extent that further catalytic defluorination is not required. Bauxite or activated alumina treatment of the product is thus eliminated and is replaced with a caustic wash system which serves as a guard against yielding traces of free HF acid to outside storage during periods of abnormal unit operation. With thermal defluorination and other design improvements, HF acid consumption is normally in the range of 0.20 pound per barrel of alkylate produced.

To remove the small quantities of acid soluble oil and trace amounts of water that accumulate in the acid, a portion of the circulating acid is continuously regenerated by fractionation. Regenerated HF acid, approximately 92 percent pure, is returned as overhead product from the rerun fractionator to the reactor, while three to four barrels per day of acid soluble oils are removed as bottoms from the column. The acid rerun fractionator is a thinly Monel-clad carbon steel vessel. This small fractionator is the only vessel in the unit using a special alloy as protection against corrosion. A limited amount of alloy trim is used on instruments, pumps, and valves.

The possible plot plan, Figure 2,

PROCESS ISSUE '55
18th Annual

New Process . . .

Meet the Authors

Rogers

Peters

WILLIAM D. PETERS has been a physical chemist and process instrument application engineer with Phillips Petroleum Company since his graduation from Emporia State College in 1947. As a physical chemist, he was given supervision of a laboratory employing infrared, ultraviolet, mass spectrometric techniques to obtain analytical data. In 1949, when automation was a new word to the petroleum industry, he was assigned to the application of composition instruments and automatic devices to various petroleum and petrochemical processes.

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CHARLES R. ROGERS is a senior sales engineer with Phillips Petroleum Company's Perco division. A chemical engineering graduate from the University of Oklahoma, he joined Phillips in 1941, after serving three years with Black Gold Refining Company. He was assigned to the Refining department's Process Design and Development section until 1950. During this period, he spent about six years in HF alkylation while working as a supervisor of still operations at the Phillips refinery in Borger, Texas.

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shows that all equipment may be laid out so that it is easily accessible for maintenance and operation. The HF acid and hydrocarbon sections are incorporated in a single unit and operated from one control room. The HF rerun unit, contactor, deisobutanizer, depropanizer, and stripper are located on one side of the overhead pipeway. All condensers, coolers, pumps, accumulators, and HF storage tanks are located on the other side. Only two men per shift are required to operate the unit.

The safety records achieved with Perco-designed HF units have been excellent and are the result of training programs based on experience, which teach associated personnel to respect but not fear HF acid. Proper methods of handling the acid and the use of protective clothing are stressed. An additional factor which has increased the safety of operating an HF unit is the fact that standard processing equipment (relief valves, pumps, etc.), correctly designed for this service, is now available.

A two-stream, Phillips-designed, Infrared Analyzer alternately analyzes the isobutane concentration of the recycle isobutane stream and a critical point in the stripping section of the deisobutanizer. The continuous analysis of the recycle stream indicates the buildup or depletion of recycle isobutane which is controlled by the operator to assure product quality. The isobutane concentration at the sample point in the deisobutanizer is correlated with the amount being lost in alkylate product. Excessive losses are eliminated by watching this analysis, resulting in economic operation. The Infrared Analyzer also reduces the number of laboratory technicians required for efficient control, as compared to units where this type of instrument is not employed.

Table 1 shows the C_4 fraction from catalytic cracking which normally has an isobutane-butylene ratio that is approximately in balance for alkylation unit feedstock. Additional olefin feed may be included and outside isobutane charged. The production of isobutane in a catalytic cracking operation eliminates the necessity of purchasing large amounts of isobutane, as was the case when the olefin feed was obtained from thermal cracking.

Table 2 summarizes the direct operating cost of an HF unit, based on a 98-percent stream factor. The average costs of labor, utilities, and chemicals indicate a total direct operating expense of $0.5360 per daily barrel of alkylate produced. An approximation of the battery limit investment for an HF unit within the range of 1000 to 3000 barrels per day can be obtained by multiplying $550 by the anticipated daily barrels of alkylate produced.

From the typical properties given in Table 3, the utility of motor fuel alkylate can be seen. The low vapor pressure and high octane of the alkylate allow the retention of considerable normal butane, plus the blending of additional, readily available, low cost natural gasoline, while maintaining specifications. The sweet character of alkylate and its inherent stability result in its highly desirable clean-burning qualities.

A manufacturer adding HF alkylation to his processing may expect an increased gasoline pool volume, improved quality, and higher octane or a decreased lead requirement.

Payouts for units of 1000 to 4000 barrels of alkylate per day capacity usually average between one and two years. ##

TABLE 1
Typical Operation 100 Barrels Per Day Total Feed

Charge to Unit	Bbl.
C_4 Fraction From Cat Cracker:	
Propane	0.9
Propylene	0.9
Butylenes	32.5
Isobutane	40.2
N-Butane	25.5
Total Unit Feed	100.0
Yields from Unit	**Bbl.**
Propane	0.9
Isobutane	1.1
N-Butane	25.5
Alkylate	56.8
Total Yield	84.3

TABLE 2
Summary of Direct Operating Expense 98 Percent Stream Factor

	Unit/Bbl. Alkyl	$/Bbl. Alkyl.
Operating Labor (2 Men/Shift)	.....	0.0800
Supervisory & Laboratory	.....	0.0800
Repair Labor & Materials	.....	0.1600
UTILITIES		
Steam at $0.18/M lb.	0.0075 M lb.	0.0014
Fuel at $0.10/MM Btu.	1.0500 MM Btu.	0.1050
Circ. Water at $0.015/M gal.	1.728 M gal.	0.0259
Make Up Water at $0.09/M gal.	0.0690 M gal.	0.0062
Electricity at $0.0057/kwh.	1.9890kwh	0.0113
CHEMICALS		
Caustic at $0.035/lb.	0.1430	0.0050
HF Acid at $0.19/lb.	0.2700	0.0510
Miscellaneous	.....	0.0100
TOTAL	.....	0.5360

TABLE 3
Typical Properties Debutanized Total Alkylate

Gravity, °API	68.8
ASTM Distillation, F.	
IBP	160
10 percent evap.	199
20 percent evap.	210
50 percent evap.	224
90 percent evap.	264
95 percent evap.	336
E.P.	392
Color, Saybolt	30
Doctor Test	Negative
Corrosion, 122 F.	Negative
Reid Vapor Pressure	3.0
ASTM Gum	0.4 Mg/100 Ml.
ASTM Research Octane Number	
Clear	93.1
1 ml TEL	100.8*
3 ml TEL	104.9†

* Equivalent to ASTM Research Method rating of 0.036 ml. TEL in Iso-octane.
† Equivalent to ASTM Research Method rating of 0.34 ml. TEL in Iso-octane.

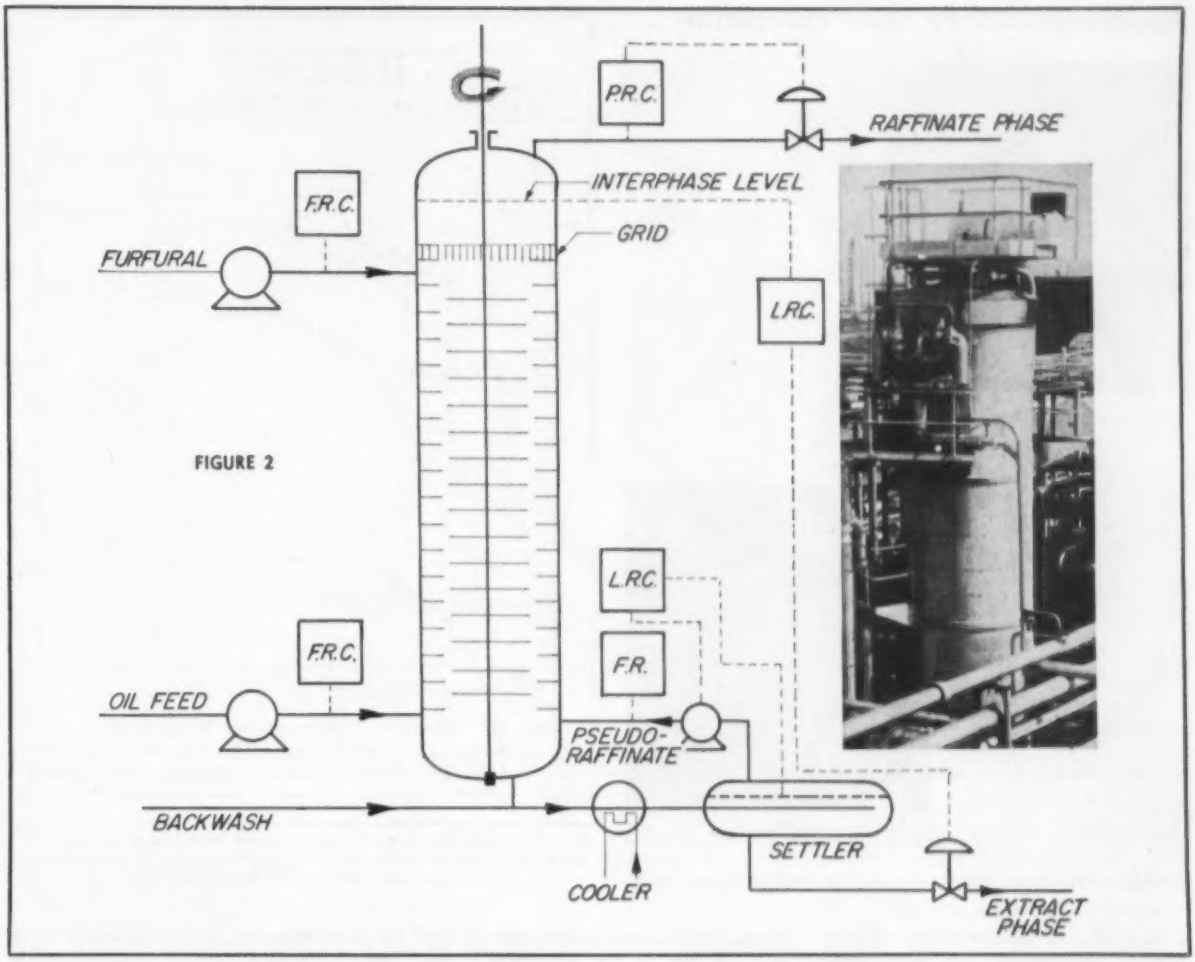

Photo (Figure 1) of rotating disc contactor in 200 bpd furfural extraction unit at Shell Haven refinery, England. Figure 2 shows the contactor consisting of a vertical cylindrical shell divided into compartments by a series of stator rings.

Applying RDC* to Lube Extraction

***Rotating disc contactor: Here's the operating data on this new counter current extraction tool, as used in the extraction of lubricating oil fractions with furfural.**

G. H. Reman and
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Koninkijke/Shell Laboratorium
Amsterdam, The Netherlands

FROM INTENSIVE research by the Shell Companies over several years in the past, a new type of countercurrent extraction apparatus—the rotating disc contactor (RDC)—has evolved. A general survey of results obtained with this apparatus has recently been published.[1] The present discussion deals specifically with its use for the extraction of lubricating oils with furfural. After the apparatus had been thoroughly tested for this purpose on a pilot plant and on a semi-commercial scale, it was applied to commercial production.

Some years of successful commercial operation have fully confirmed the optimistic expectations set up by the small-scale experiments. At present five contactors are in use in various luboil plants (see Figure 1). All show a very good performance.

It has been proved that for lubricating oil extraction with furfural the apparatus possesses a high volumetric efficiency, and since the contactor retains this high efficiency over a wide capacity range, it also has a great flexibility in operation. Furthermore, the apparatus is easy and cheap to operate and maintain, and because of

PROCESS ISSUE '55
18th Annual

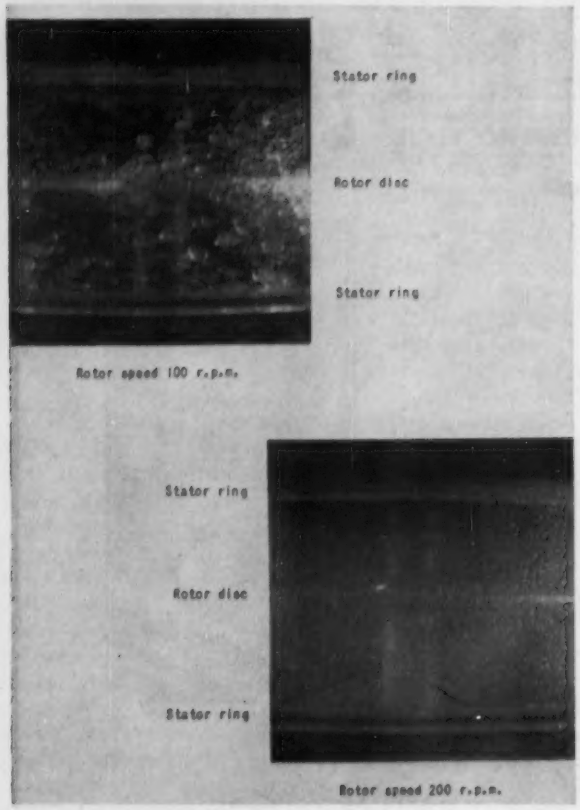

FIGURE 3—Droplet size can be controlled by variation in rotor speed.

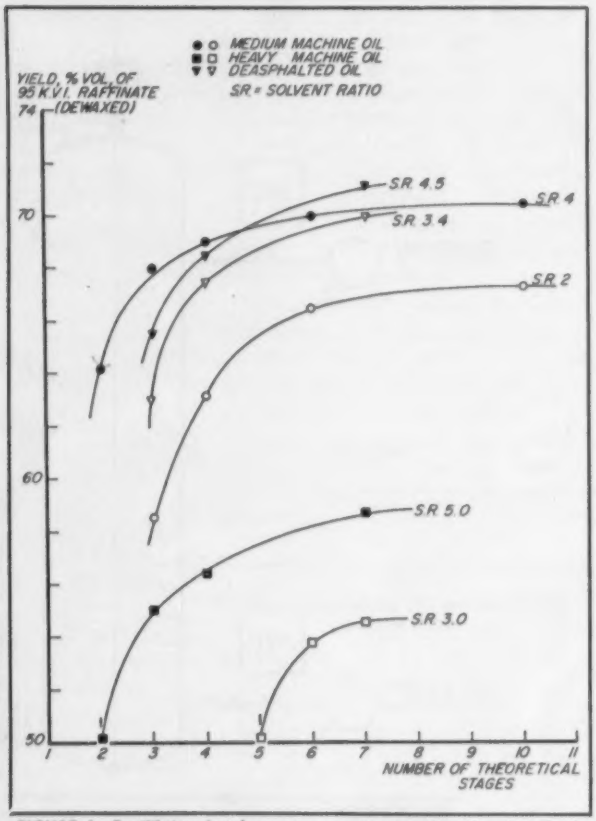

FIGURE 4—Equilibrium batch countercurrent extraction of various feedstocks: How number of theoretical stages affects yield of waxy raffinate for a raffinate quality of 95 K.V.I. (dewaxed).

its simple and straight-forward construction it costs less to build than any other existing apparatus of comparable efficiency.

Construction and Mode of Operation—The contactor (Figure 2) consists of a vertical cylindrical shell divided into a number of compartments by a series of stator rings. A rotating disc supported by a rotating shaft is centered in each compartment.

Adjacent to the top and bottom compartment there are the feed inlets, which are arranged tangentially in the direction of rotation. Furfural and oil are introduced into the contactor through the top and bottom inlet respectively. By the action of gravity, the countercurrent flow of a furfural and an oil phase is established. Owing to the action of the rotating discs one of the phases will be dispersed. The size of the droplets formed is determined by the speed of the rotor discs in the compartments. Variation in the rotor speed provides a simple and effective method of obtaining optimum extraction conditions. The feature of drop size control is illustrated in the adjoining photographs (Figure 3) of a plastic model of one compartment, showing water drops dispersed in kerosine.

In the case of the extraction with furfural of lubricating oils, the furfural is in general maintained as the continuous phase in order to obtain the most efficient operation. The top of the contactor then acts as settling zone. An extra stator ring and a wide mesh grid are fitted into the shell to separate the furfural inlet zone from the settling compartment. This design has proved to be very effective in obtaining undisturbed settling and coalescence of the oil drops in the settling compartment.

Another feature that is applied in the extraction with furfural of lubricating oils is backwash. For this purpose an external cooler and a bottom settler are provided, through which the extract phase leaving the contactor is passed. By the reduction in temperature a pseudo-raffinate phase separates from the extract phase. This pseudo-raffinate coalesces in the settler and is returned to the contactor by a small pump with flow control, which is preferably, but not necessarily, actuated by the level in the settler. An external backwash can also be applied by injection into the extract phase from the contactor ahead of the cooler.

The extract phase is taken off from the bottom settler. Its flow rate is controlled by the interphase level in the top settling compartment. The raffinate phase overflows from the top of the contactor. If the contactor is operated, as is usually the case, at a pressure of 30 to 60 psig in order to force the phases directly to the respective recovery units, the offtake of raffinate phase is regulated by pressure control.

Separating Power of the Contactor—In lubricating oil extraction, the efficiency of extraction can be expressed in terms of raffinate yield for a certain raffinate quality. The quality is usually judged by the viscosity index (KVI).

In Figure 4 characteristic results are given for the extraction of lube

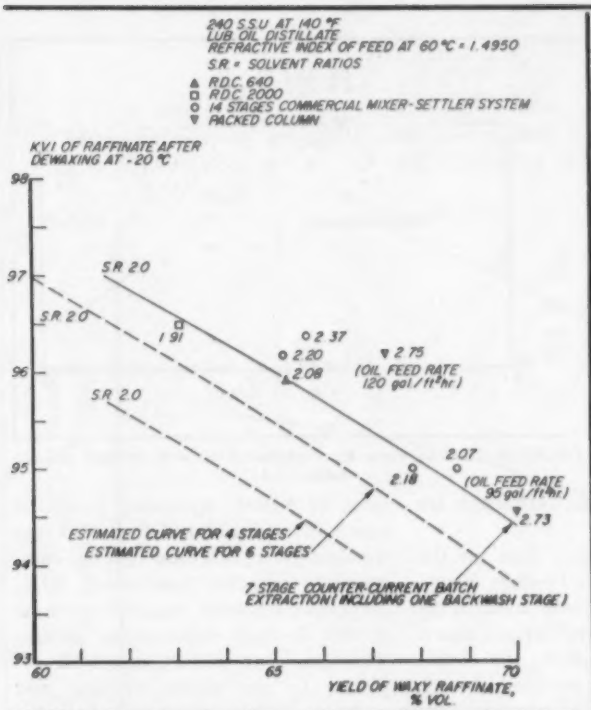

FIGURE 5—Extraction of medium machine oil distillate with furfural (240 S.S.U. at 140 F.).

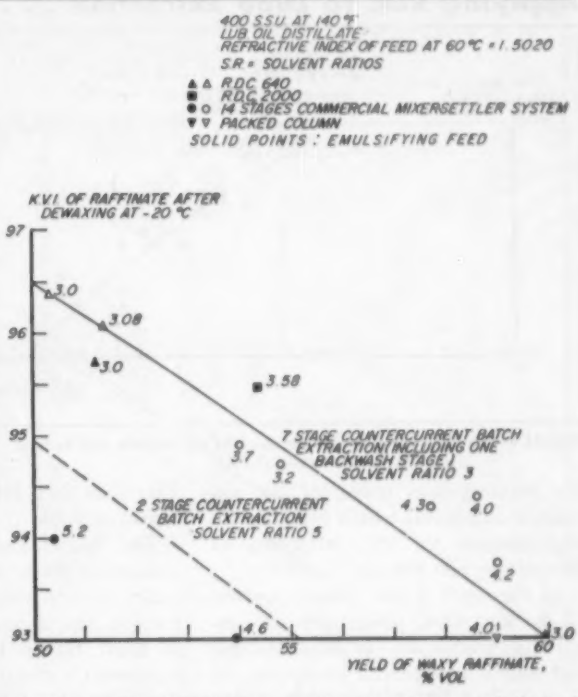

FIGURE 6—Extraction of heavy machine oil distillate with furfural (400 S.S.U. at 140 F.).

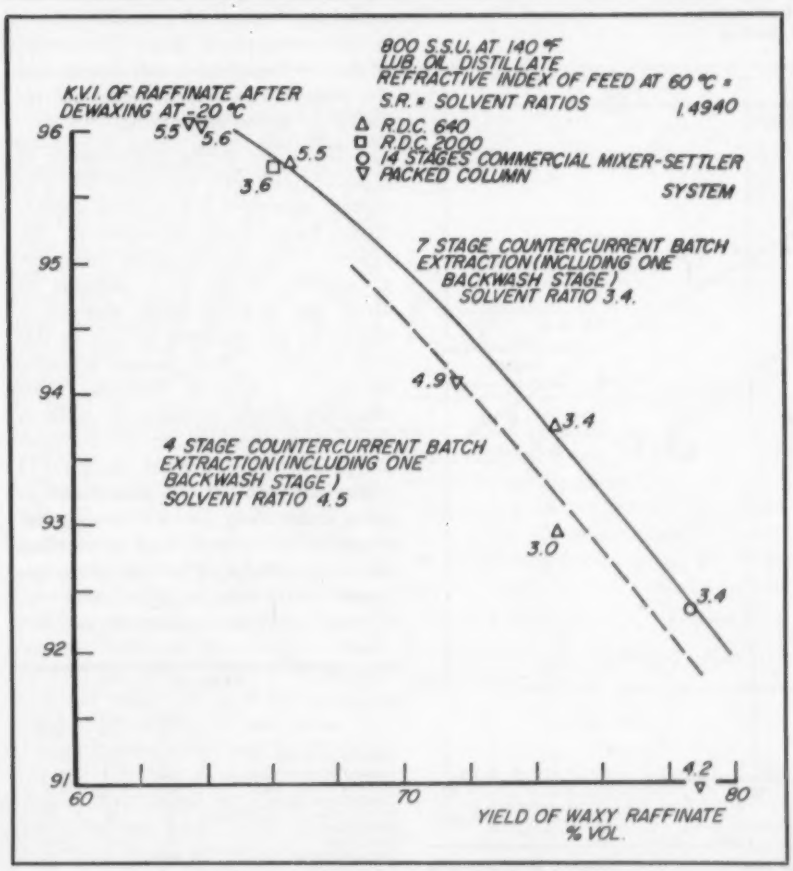

FIGURE 7—Extraction of deasphalted oil with furfural.

oil fractions with furfural. The data were obtained from equilibrium batch countercurrent extractions with various numbers of stages, the temperature being in all cases so adjusted that the raffinate had 95 KVI after dewaxing. The curves clearly show that the solvent ratio (furfural to feed) required for a given separation diminishes as the number of stages increases. Furthermore it appears that seven theoretical stages are about the maximum that can be usefully applied. There is little to be gained by using more than seven stages; however, a decrease in the number of stages below seven soon leads to appreciably poorer extraction. Apparatus having a separating power of seven or slightly more than seven theoretical stages must therefore be considered ideal for the extraction of lubricating oil with furfural.

Up to the present the conventional apparatus for performing the extraction of lubricating oils with furfural was either deficient from the standpoint of separating power, or if adequate in this latter respect, costly to build and operate. With the advent of

PROCESS ISSUE '55
18th Annual

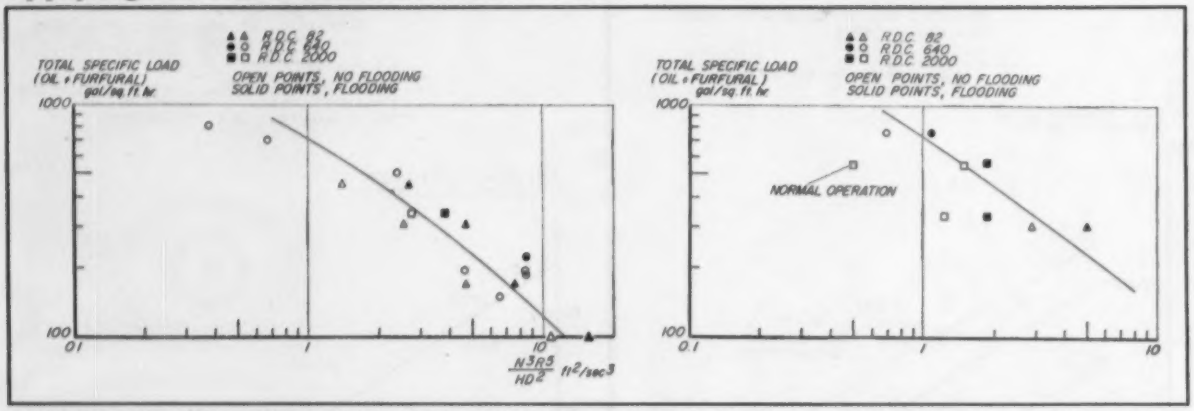

FIGURE 8—Flooding curve for medium machine oil distillate with furfural (solvent ratio = 2.0).

FIGURE 9—Flooding curve for deasphalted oil with furfural (solvent ratio = 3.4).

the rotating disc contactor, an extraction apparatus which fully met all requirements for the extraction of lubricating oils became available.

In Figures 5, 6 and 7 data are given on the separating power of two rotating disc contactors—a semi-commercial and a commercial unit—for the extraction of lubricating oil fractions. Technical data for the contactors are shown in Table 1.

The figures also give data on the separating power of a 14-stage mixer-settler system which was installed by Shell in one of its first furfural plants at Shell Haven in order to obtain maximum raffinate yields. Although this system came fully up to expectations as regards separating power, it was costly to build and operate. From the data given, it is clear that the commercial contactor mentioned, RDC 2000, has the same separating power as the 14-stage mixer-settler system. The latter has, in fact, now been replaced by the above rotating disc contactor. The cost of this contactor is estimated to be less than 50 percent of the mixer-settler system. Furthermore, the holdup of valuable solvent in the contactor is about 10 percent of that in the mixer-settler system and the unavoidable solvent losses are reduced by about 30 percent.

A few data on the performance of a packed column—the generally employed apparatus for furfural extraction—have been included in the figures. It should be noted that with a packed column it is difficult to attain the desired seven theoretical stages, even if columns as high as 100 feet are used. The packed column, moreover, has poor flexibility. The efficiency drops considerably with a decrease in the load on the column. In practice the normal technical packed column may be considered to have from four to six theoretical stages in the extraction of lubricating oils with furfural. The data given indicate that a rotating disc contactor, 22 feet high, has the same or an even

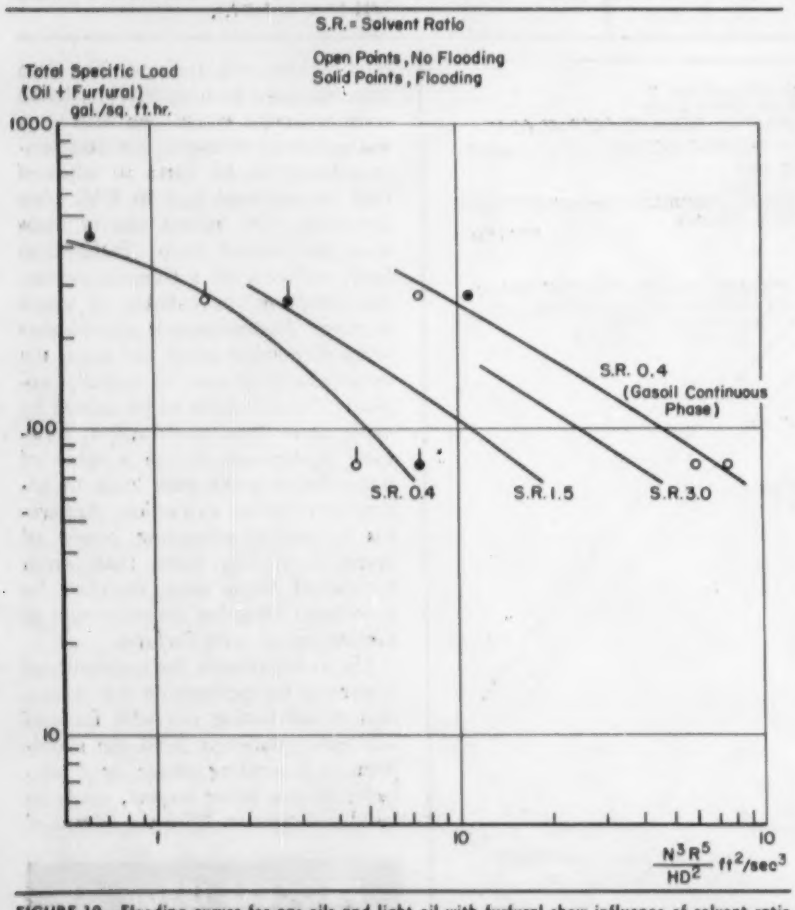

FIGURE 10—Flooding curves for gas oils and light oil with furfural show influence of solvent ratio (furfural continuous phase).

TABLE 1

	RDC 82	RDC 640	RDC 2000
Diameter of column	3.2"	2'-1"	6'-6"
Diameter of stator rings	2.55"	1'-4"	4'-5"
Diameter of rotor discs	2.2"	1'-0"	3'-4"
Compartment height	0.8"	4.7"	10"
Total number of compartments	75	30	20
Effective height	5'	11'-10"	16'-8"
Total height	6'	13'-8"	22'-2"
Rotor speed rpm	400	60	25
Power input hp	..	≈ 0.1	<1

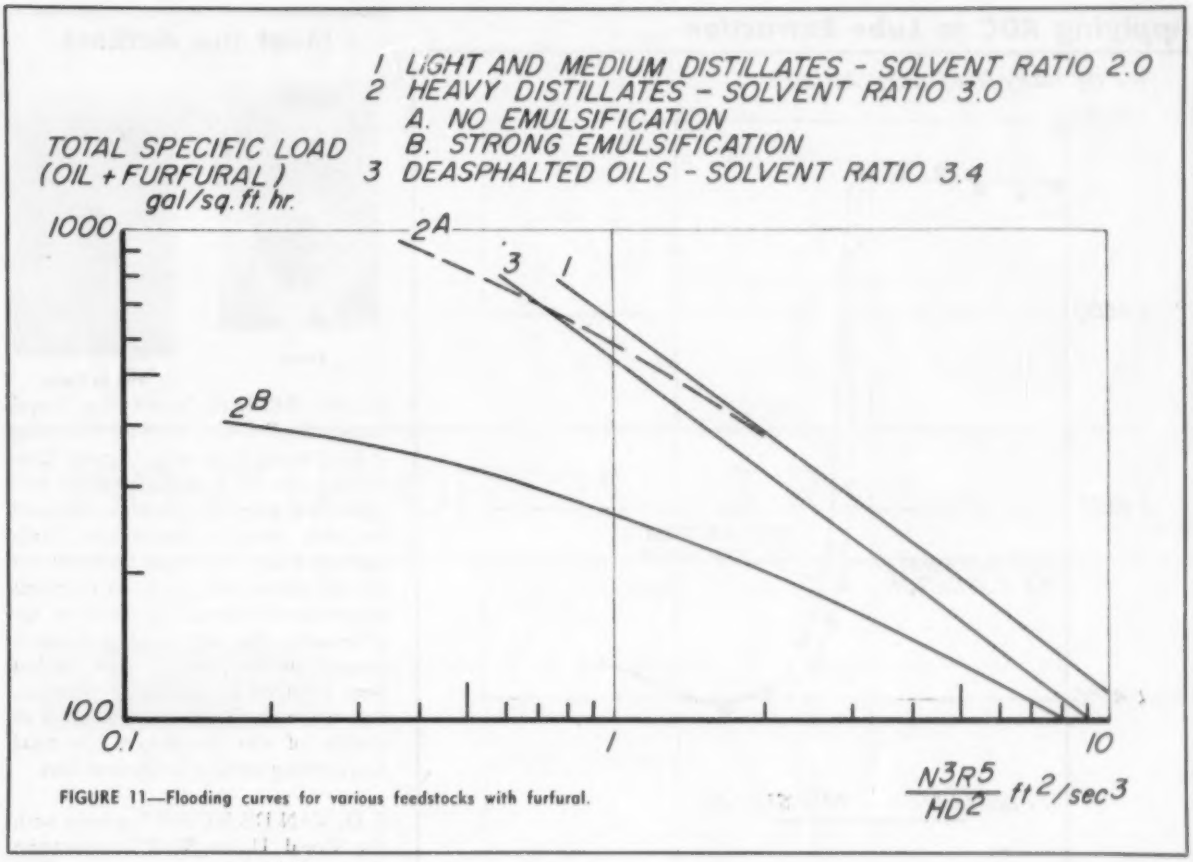

FIGURE 11—Flooding curves for various feedstocks with furfural.

better separating power than a packed column of more than 100 feet in height. As, moreover, the specific load for the contactor is at least as high as that for a packed column, Shell decided to install rotating disc contactors in their new luboil plants at Pernis and Buenos Aires. The cost of these contactors is only 30 to 40 percent of the cost of packed columns that would be needed for the purpose in view. All contactors are now in operation and perform very satisfactorily.

Capacity of Contactor—The conditions under which flooding occurs in the contactor form the limits of controlled operation and these data are consequently of vital importance both for design and operation. In the case of lube oil extraction, where furfural is the continuous phase, flooding manifests itself by a rapid rise in oil content in and below the bottom compartment, and in a sudden increase in flow of pseudo-raffinate phase. If allowed to continue, this state is soon followed by a reversal of the phases, and a serious deterioration of the performance of the apparatus.

TABLE 2

OIL	Viscosity SSU at 140 F.	Temp. F.	PACKED COLUMN Solvent Ratio	PACKED COLUMN Oil Feed Rate, Gal./Hr. Sq. Ft.	ROTATING DISC CONTACTOR N^3R^5/HD^2 Ft³/Sec.³	ROTATING DISC CONTACTOR Solvent Ratio	ROTATING DISC CONTACTOR Oil Feed Rate Gal./Hr. Sq. Ft. Flooding Rate	ROTATING DISC CONTACTOR Oil Feed Rate Gal./Hr. Sq. Ft. Design Rate (=65% of Flooding Rate)
Gas oil		120	0.4	180	3	0.4	490	320
Spindle and medium machine	240	160-210	3.0	160	0.5	2.0	370	240
Heavy machine	400	210	4.0	100	0.5	3.0	215	140
Deasphalted residue	800	210	4.5	70	0.5	3.4	240	155

Note: In the case of a packed column the oil phase is mostly taken as the continuous phase; for RDC operation the furfural phase is the continuous phase except for gas oil.

The flooding capacities for various feedstocks have been determined and could be correlated with the structural variables of the contactor. It appeared that, for a given feedstock extracted at constant solvent ratio, the total specific load $(v_d + v_c)$ is a function only of a quantity $\left(\frac{N^3 R^5}{H D^2}\right)$, which is proportional to the energy input of the rotating discs.

SYMBOLS

D = diameter of column, ft.
R = diameter of rotor disc, ft.
H = height of compartment, ft.
N = rotorspeed, revs./sec.
v_d = superficial velocity of dispersed phase, gal./ft.², h
v_c = superficial velocity of continuous phase, gal./ft.², h

Figures 8, 9 and 10 give proof of the reliability of this capacity correlation for a distillate and deasphalted oil fraction respectively. In Figure 11 capacity curves for various types of oil are given.

In connection with these curves it may be remarked that at higher solvent ratios the total allowable thruput is higher, but the oil rate slightly lower. In the case of heavy distillates emulsification phenomena caused by bottom pitch contamination during

PROCESS ISSUE '55
18th Annual

Applying RDC to Lube Extraction . . .

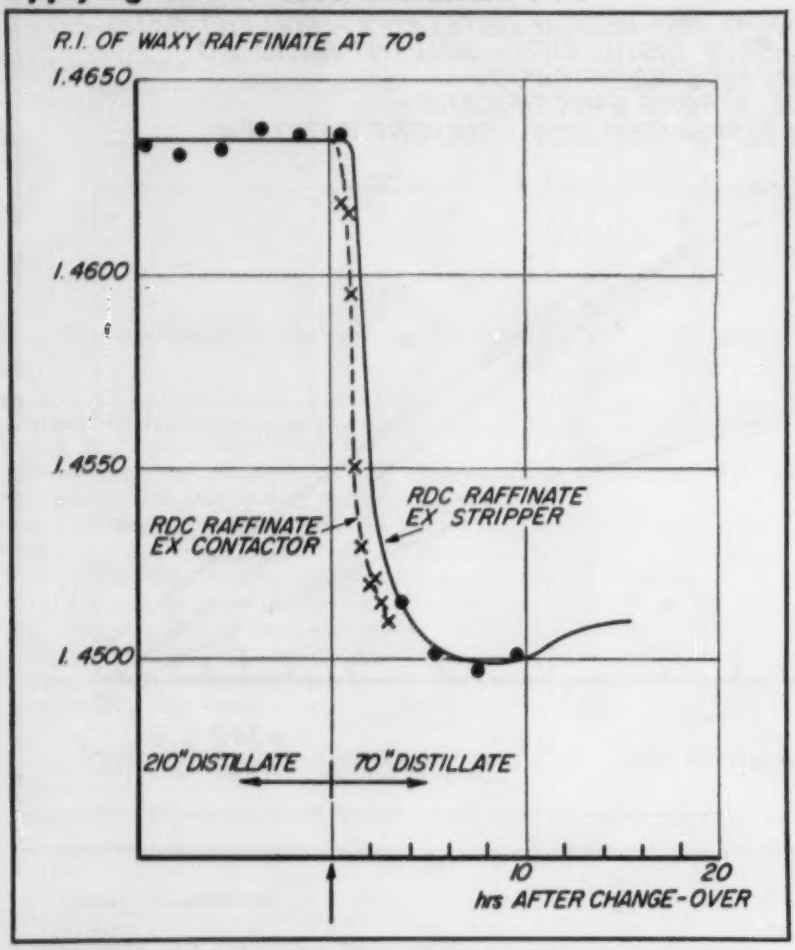

FIGURE 12—Change of refractive index with time for change of grade-210 seconds distillate to 70 seconds distillate.

distillation are not uncommon. The emulsifying tendency of the feed is reflected in the capacity, which may, in the worst cases, be a factor 2.5 lower. With a view to efficiency the rotating disc contactor is usually operated at an energy input equivalent to a value of 0.5 ft.²/sec.³ for the quantity $\frac{N^3 R^5}{H D^2}$. This leads then to capacities for the various oils indicated in Table 2. In this table a comparison has also been made with capacity data for packed columns. The data show that the allowable specific load is possibly even higher in the case of the rotating disc contactor.

Summing Up—It has already been indicated that the rotating disc contactor possesses an excellent separating power in luboil extraction with furfural. As a result, the solvent ratios employed in the extraction of various fractions are slightly lower than those used in a packed tower. Table 3 gives typical data and results for the extraction of luboil fractions obtained from a Venezuelan crude oil.

The great flexibility of the contactor may best be illustrated by mentioning the case of a heavy distillate which could barely be processed at all, in the 14-stage mixer-settler system already mentioned, because of emulsification difficulties. This same distillate processed very smoothly in the rotating disc contactor in spite of the fact that the maximum permissible load on the contactor was somewhat lower. With the normal solvent ratios employed, the separating power, even in the case of this feedstock with high emulsifying tendency, proved to be seven theoretical stages.

Another valuable feature of the contactor is that it allows a very quick change-over of feedstock. Only very small quantities of off-grade products are obtained. Figure 12 shows the response of product streams to a change-over of feed stock.

TABLE 3

Oil Viscosity SSU at 140 °F.	Solvent Ratio	TEMPERATURE °F. Top	Settler	Oil Inlet	REFRACTIVE INDEX n_D/70 °C. Feed	Raffinate	K.V.I.	Yield, Percent Vol.
50″ Spindle	2	220	200	165	1.4810	1.4530	..	65.0
285″ Medium machine oil	2	250	195	185	1.4920	1.4630	95	65.0
400″ Heavy machine oil	3-3.6	255	205	195	1.4990	1.4635	95	55.0
600″ Deasphalted oil	3.4	240	185	175	1.4880	1.4740	95	76.0
	3.7	265	235	210	1.4930	1.4745	95	67.0

ACKNOWLEDGMENT

The authors wish to thank the management of The N. V. DeBataafsche Petroleum Maatschappij, The Hague, Netherlands for permission to publish the above account and gratefully acknowledge the assistance of those who co-operated in the work.

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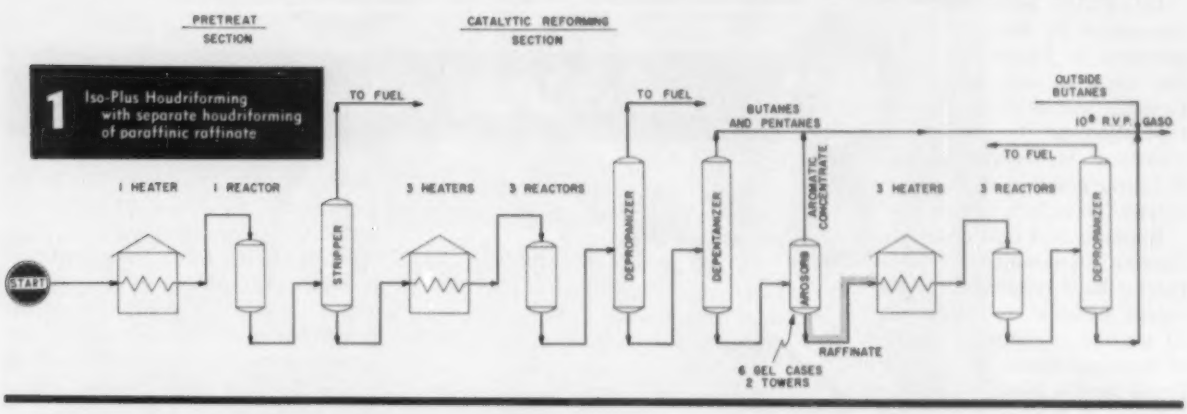
Meet the Authors

Reman

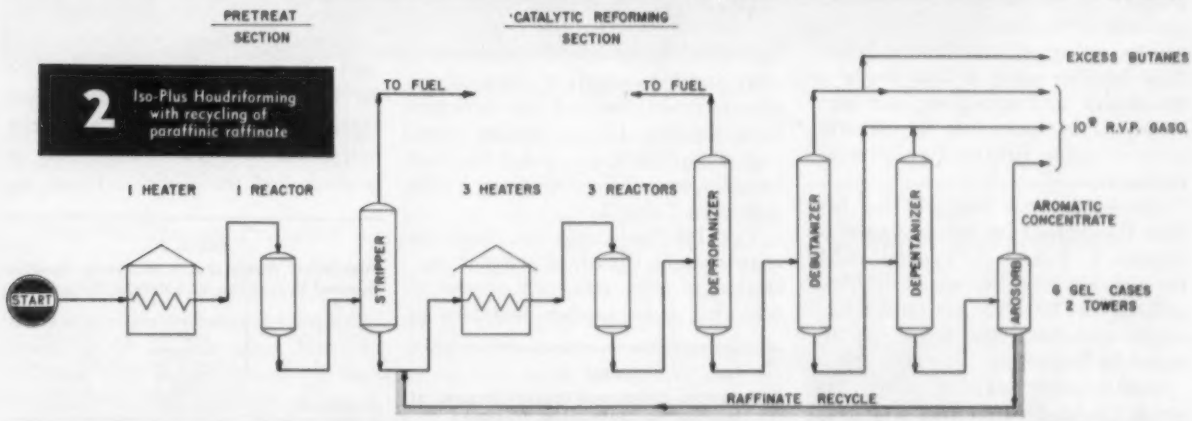
Van de Vusse

G. H. REMAN joined the Royal Dutch/Shell Group in 1937, following a long association with Utrecht University, first as a physics student and later in a research position. Assigned to the group's Koninklijke/Shell-Laboratorium, he began carrying out investigations into pre-flame reactions occurring in internal-combustion engines and the action of anti-knock drops. For the past 15 years, he has been engaged in developing physical-separation methods. Dr. Reman is in charge of the company's Chemical Engineering section at Amsterdam.

J. G. VAN DE VUSSE has been with the Royal Dutch/Shell organization since 1948. He joined the group shortly after completing his doctorate in technical physics at Delft University. Since then, he has been assigned to chemical engineering problems.



ISO-PLUS OFFERS 3 Routes . . .



. . . TO HIGHER Octane Gasoline

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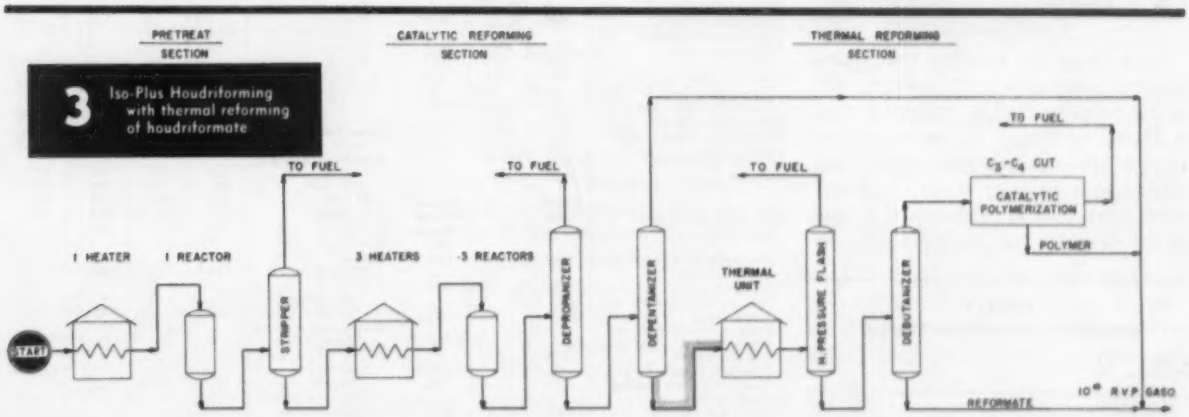


PROCESS ISSUE '55
18th Annual

one variation yielded 108 octane

ISO-PLUS HOUDRIFORMING, announced by Houdry Process Corporation in March, 1955, combines the conventional catalytic Houdriforming process with either aromatics separation or thermal reforming to transform low-octane naphthas into F-1 clear gasoline in the range of 100 octane and higher, at high yield levels.

Experimental runs of aromatics extraction variations of the Iso-Plus process have resulted in yields of 100 octane gasoline, F-1 clear, of up to 91 percent of naphtha charge. One of these variations, with slight operational modification, yields 82 volume percent of feed as 103 octane F-1 clear gasoline.

Pilot plant and refinery Iso-Plus processing, with thermal reforming as the supplementary process, yields 80 percent to 90 percent of reformed gasoline, depending upon the desired octane rating of the final product. This Iso-Plus route is least costly in investment and operation, and may be especially attractive to refineries with available thermal reforming equipment.

Schematic flow diagrams for Iso-Plus Houdriforming are presented in Figures 1, 2 and 3. Typical yields for each variation appear in Table 2 utilizing a 200-394 F. (A.S.T.M.) virgin naphtha whose properties are shown in Table 1.

Other tables present pilot plant yields for Iso-Plus thermal reforming of 84 and 89 F-1 clear catalytic reformates, and refinery processing of an 80.5 F-1 clear catalytic reformate by the Iso-Plus thermal variation.

1 & 2. Iso-Plus Aromatics Extraction Combinations

In each of the Iso-Plus routes employing aromatics extraction, the virgin naphtha feed is charged first to a Houdriformer pre-treat section (heater and catalytic guard-case) and thence to a stripper tower. H_2S and other contaminants are vented to fuel in the stripper, and the main effluent stream then moves to the Houdriformer's three heaters and catalytic reactors in series.

In one of these Iso-Plus schemes, diagrammed in Figure 1, the 87 F-1 clear Houdriformed effluent is flashed, depropanized and dependentanized, with butanes and pentanes going to product. Dependentanized effluent is charged to aromatics extraction, and a 91 percent aromatics concentrate is separated as product.

An 81 percent paraffinic raffinate is moved to a second Houdriforming stage, yielding 81 F-1 clear Houdriformate for flashing and depropanizing. Final blend of 100 octane F-1 clear gasoline consists of the aromatic concentrate, butanes and pentanes from the first Houdriforming stage, and depropanized Houdriformate from the second Houdriformer. Yields appear in Table 2.

This Iso-Plus aromatics extraction route may be slightly changed in operation to offer refiners a means of achieving even further increases in gasoline product octane. Recycling second-pass reformate to aromatics extraction, thereby ultimately converting paraffins to 91 percent aromatic concentrate, pentanes and lighter, makes it possible to recover more than 80 percent of naphtha feed as 108 F-1 clear octane ten-pound RVP gasoline.

The Iso-Plus aromatics extraction route, diagrammed in Figure 2, eliminates the second Houdriformer in the scheme previously described, and provides for depropanizing, debutanizing and dependentanizing of an 83 F-1 clear Houdriformate from the single reformer stage. Most of the butanes and part of the debutanized reformate go to final product. Dependentanized Houdriformate undergoes aromatics extraction, with concentrate going to product and paraffinic raffinate re-

TABLE 1

Inspections of Reformer Charge

Gravity, °A.P.I.	51.0
Distillation, °F.:	
I.b.p.	200
10 percent	230
50 percent	295
90 percent	365
End point	394
Sulfur, weight percent	0.125
F-1 clear octane	54.1
Composition, volume percent:	
Paraffins	46
Olefins	...
Naphthenes	37
Aromatics	17

TABLE 2

Comparative Yields and Process Streams of Iso-Plus Houdriforming Processes

	Houdriforming Plus Aromatics Extraction		Houdriforming Plus Thermal Reforming
Feed to pre-treater (BPSD)	6600	6600	6600
Recycle raffinate	....	3531	....
Total reformer feed	6600	10,131	6600
Yields from reforming:			
Reformate, C_5+	5003	8753	5900
Butanes	271	574	271
Fuel gas, F.O.E.	422	818	422
Reformate octane, F-1 clear	87.0	83.0	87.0
Charge to debutanizer	....	9327	6171
Charge to dependentanizer	6171	7068	....
Dependentanizer bypass stream	....	1685	....
Aromatic charge	5603	6545	....
Aromatic concentrate	3174	3014	....
Raffinate	2429	3531	....
Yields from second pass Reforming:	Houdriform Raffinate		Thermal Reform Reformate
Reformate, C_5+	1932	....	4807
Heavy polymer	....	....	33
Butanes	246	....	143
Butenes, recovered for cat. poly chg.	....	....	272
Propene, recovered for cat. poly chg.	....	....	183
Fuel gas, F.O.E.	293	....	491
Reformate octane, F-1 clear	81.0	....	99.6
Catalytic polymer gasoline	....	....	328
Over-all yields:			
Butane free gasoline	5403	5222	5135
Butanes for 10-lb. RVP	590	529	536
Total 10-lb. RVP gasoline	5993	5751	5671
Excess butanes	*73	45	*122
Fuel gas, F.O.E.	715	818	913
F-1 clear octane of 10-lb. RVP Gasoline	100.0	100.0	100.0

* Outside butanes required.

TABLE 3

Pilot Plant Yields and Inspections, Iso-Plus Thermal Processing of Catalytic Reformates

Charge Stock	84 F-1 Clear Catalytic Reformate from E. Tex. Naphtha 260-385 F. (ASTM)		89 F-1 Clear Catalytic Reformate from E. Tex. Naphtha 260-385 F. (ASTM)	
	Weight Percent	Vol. Percent	Weight Percent	Vol. Percent
Yields:				
C_5+ Reformate	74.5	71.8	81.0	78.6
Tar	5.6	4.5	3.9	3.2
Dry gas, C_3 and lighter	13.8	.....	10.1	.....
Pentenes	2.4	2.9	2.5	3.1
Pentanes	2.0	2.6	2.1	2.7
Butenes	3.6	4.8	3.1	4.1
Butanes	2.5	3.5	1.9	2.7
Propene	2.8	.....	2.5	.....
Potential Catalytic Polymer (Calc.) (*)	5.0	5.4	4.3	4.7
Inspections:	C_5+	Heavy Polymer	C_5+	Heavy Polymer
Gravity, API	39.2	8.5	39.2	9.6
Distillation, ASTM, F.				
IBP	130	465	134	492
10 percent	205	516	208	530
50 percent	298	592	296	587
90 percent	364	.....	364	700
EP	426	.....	420	.....
RVP	3.5	.....	3.2	.....
Octanes				
F-1 clear of C_5+	99.6	.....	100.0	.....
F-1 clear of C_5+ and Catalytic Polymer (Calc.)	100.0	.....	100.3	.....
Composition of Heavy Polymer Free C_5+ Reformate				
Paraffin, vol. percent	12.2	.....	13.1	.....
Olefin, vol. percent	5.6	.....	4.5	.....
Naphthene, vol. percent	2.8	.....	1.9	.....
Aromatic (Alkyl-Benz) vol. percent	76.3	.....	77.4	.....
(Alkenyl), vol. percent	3.1	.....	3.1	.....

(*) Assumes 95 percent recovery of butenes, 75 percent recovery of propene, 90 percent conversion to polymer.

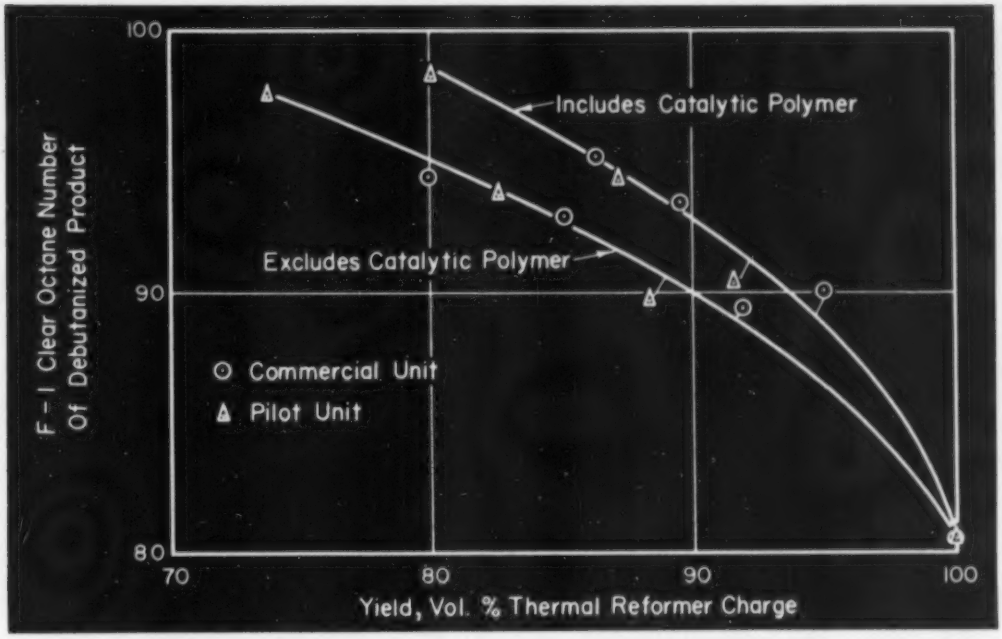


FIGURE 4—How commercial results agree with pilot plant data.

cycling to the main feed stream to the Houdriforming section. See Table 2 for yields.

3. Iso-Plus Thermal Processing

As diagrammed in Figure 3, a third Iso-Plus Houdriforming variation pretreats, strips and reforms the naphtha charge to an 87 F-1 clear Houdriformate. This is depropanized and depentanized, with propanes going to refinery fuel, and butanes and pentanes taken for final blending. The depentanized effluent is thermally reformed, flashed, and debutanized, with the C_3-C_4 cut going to catalytic polymerization and resultant polymer gasoline going to blending with debutanized reformate, butanes and pentanes. Table 2 compares yields for this Iso-Plus route with those for aromatics extraction variations.

Inasmuch as refiners with available thermal reforming equipment may be confronted with immediate need for higher gasoline product octane number, additional pilot plant and commercial data are presented for Iso-Plus processing in the thermal reforming combination. These data appear in Tables 3 and 4, and a comparison of commercial and pilot plant results is shown in Figure 4.

TABLE 4

Refinery Iso-Plus Thermal Reforming of 80.5 F-1 Clear Catalytic Reformate

Plant Operating Data	
Charge rate, BPD	5700
Charge octane number, F-1 clear	80.2
F-1 at 3cc TEL/gallon	92.4
Product (C_5—440-F) yield, vol. percent	80.0
F-1 clear octane number	94.4
Total potential debutanized gasoline yield (*)	86.4
F-1 clear octane number	95.2
Heater outlet temperature, F	1000
Heater inlet pressure, psig	850
Heater outlet pressure, psig	615

Product Yields	**Vol. Percent**	**Wt. Percent**
Dry gas, C_3 and lighter	....	10.1
Butanes	8.7	6.6
C_5 to 440-F gasoline	80.0	80.9
440-F to EP heavy polymer	1.9	2.4
Light hydrocarbon breakdown:		
Methane and hydrogen	....	1.4
Ethylene	....	0.7
Ethane	....	2.1
Total C_2 and lighter	....	4.2
Propylene	4.0	2.7
Propane	5.0	3.2
Isobutane	0.5	0.3
Isobutylene	2.4	1.8
Normal butylene	3.9	3.1
Normal butane	1.9	1.4

(*) Includes catalytic polymer from propylenes assuming 75 percent recovery and 90 percent conversion plus catalytic polymer from butylenes at 95 percent recovery and 90 percent conversion.

Summary—Motor gasolines of the high-octane levels required today and likely to be required in increasing amounts in the foreseeable future may be produced economically by any of three Iso-Plus processing routes incorporating Houdriforming in combination with supplementary processing.

Iso-Plus Houdriforming in combination with aromatics separation provides the highest potential for both octane number and yield of motor gasoline. Iso-Plus Houdriforming in combination with thermal reforming may be particularly attractive to refiners with available thermal reforming equipment. ##

Meet the Author

HENRY D. NOLL is director of engineering for Houdry Process Corporation, and previously headed the company's Engineering and Technical Service division. Educated at the universities of Colorado and Pittsburgh, he began his career with Standard Oil Company of New York, later becoming associated with Magnolia Petroleum Company as development supervisor at Beaumont, Texas. He joined Houdry in 1944 after several years in charge of thermal- and catalytic-cracking research at the Socony-Vacuum Oil Company laboratories in Paulsboro, N. J. With Houdry, he has been manager of the Project Analysis department and served as technical consultant to Houdry licensees.

PROCESS ISSUE '55
18th Annual

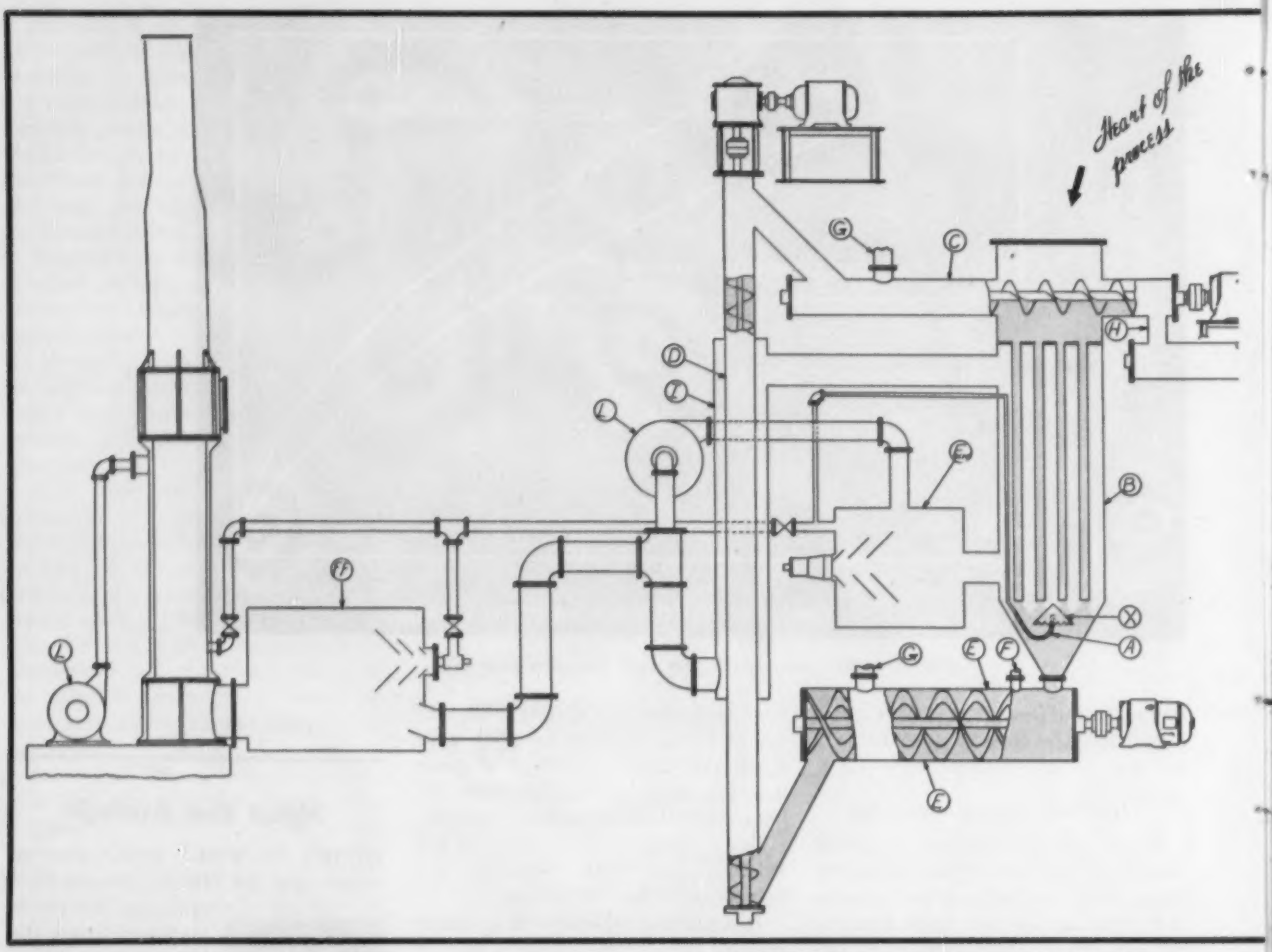


FIGURE 1—Equipment diagram for acid sludge recovery

WHAT TO DO WITH ACID

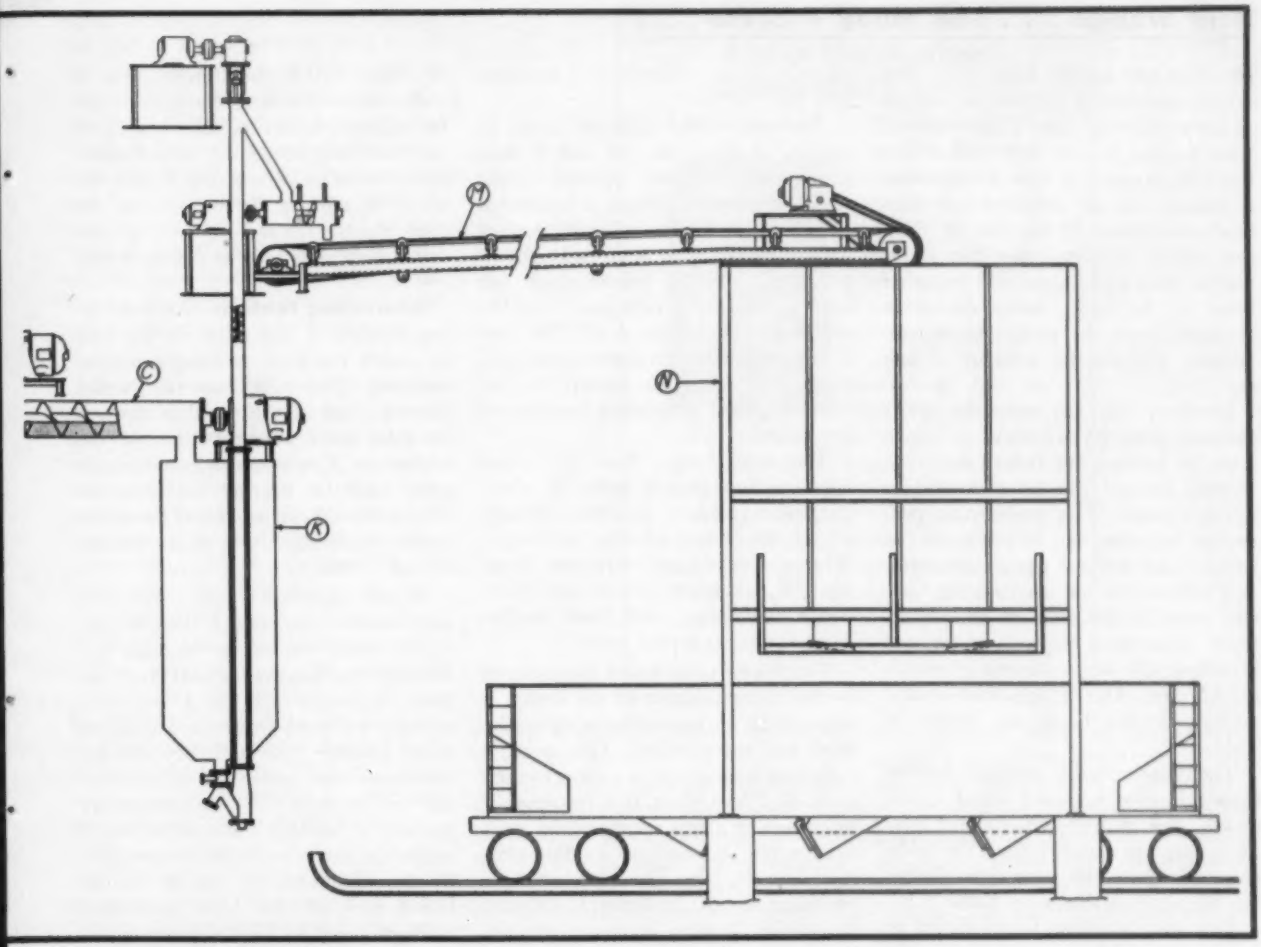
G. Hunter Miley
Daugherty Refinery,
Petrolia, Pa.

A NEW PROCESS for the utilization of refinery acid sludge has been developed at L. Sonneborn Sons' Daugherty refinery. The process employs a continuous cycle, carried out in a specially designed retort. At the start of the cycle, acid sludge is mixed with hot coke. As a result of its contact with the hot coke, the sludge decomposes to yield highly concentrated sulfur dioxide and additional coke. Further on in the cycle, after the sulfur dioxide evolution is practically complete, the coke is heated sufficiently to drive off part of its volatile hydrocarbon content. Excess coke is removed and the remaining coke goes on to be mixed with fresh incoming sludge.

The treatment of petroleum products with sulfuric acid is a procedure that has been used for many years. The methods of treatment differ greatly and a wide variety of finished products is produced by acid refining. Among them are white oils, lube oils, and alkylates. In practically every case, the spent acid from the treatment forms a dark sludge which creates a major problem since its disposal is necessary in order to avoid pollution. It is, therefore, not surprising that the acid sludge disposal plant in most refineries is considered successful as long as it disposes of its quota of acid sludge, even if it operates at a small loss.

At L. Sonneborn Sons' Daugherty refinery in Petrolia, a new process has been developed for disposing of acid sludge. The plant which uses this process is a sludge conversion plant rather than merely a disposal plant; for it converts the sludge into valuable products and does so on a profitable basis.

Raw Materials—In describing this plant it is useful to consider first its raw materials and products. One type of feed for the plant is acid sludge obtained from white oil refining. Actually, even white oil sludge is extremely variable in composition. For example, its titratable acidity can vary from 30 to 90 percent H_2SO_4. A typical white oil sludge, which we will



process: Purer SO_2 than from a sulfur burner.

SLUDGE ...The Miley Process

designate "prototype sludge" has the analysis shown in Table 1.

While the prototype sludge exemplifies the feed going to the plant today, it is believed that any acid sludge can be converted by the new process as long as it is pumpable and cokeable. The pumpability requirement is necessary in order for the sludge to be delivered to the plant in the proper form, and the sludge must be cokeable in order to produce the discrete, hard coke particles on which the functioning of the process depends.

TABLE 1
Analysis of Prototype Sludge

Percent Acid (H_2SO_4)	54.0
Percent Water	8.0
Percent Hydrocarbon	38.0
Total	100.0
Viscosity, SSU at 100° F	6,400
Color	Black

New process decomposes sulfuric acid sludge to coke and high purity SO_2.

Unique Retort—The heart of the plant is a unique retort into which the sludge is fed. The retort produces sulfur dioxide and coke as its main products. A variable quantity of hydrocarbon vapors is also produced but these vapors are profitably used as part of the fuel required by the retort so that they are consumed in the process.

Referring to Figure 1, two outlets, G, are provided in the retort for the sulfur dioxide. By far the larger quantity comes from the lower outlet near where the sludge and coke first meet. A relatively small quantity of sulfur dioxide is taken from the upper out-

let. The gas issuing from these two outlets contains a greater percentage of sulfur dioxide than a gas obtained from a sulfur burner. The explanation for this paradox is that when sulfur is burned the air required for combustion contains 79 percent of nitrogen which contaminates the sulfur dioxide that is produced. On the other hand, in the retort, sulfur dioxide is obtained from the sludge by decomposition without the addition of any air.

However, the gas from the retort contains some hydrocarbons which must be burned out before its sulfur dioxide content can be converted to sulfur trioxide. This purification procedure is carried out in a furnace (to which some natural gas is admitted) and followed by water-scrubbing, Cottrell precipitation, and oxygen adjustment. After these steps, the retort gas is comparable to gas derived from sulfur burning. The comparative analyses, on a dry basis, are given in Table 2.

The other valuable product derived from the retort is a coke, which is low in ash, low in acid content and relatively large in particle size. The coke obtained from the prototype sludge has the analysis shown in Table 3.

This coke has been found useful as a raw material for activated charcoal and for the manufacture of carbon disulfide.

Process Explained—The process can be best understood by referring to Figure 1. Basically the retort provides a closed path for the circulation of coke and sludge. The sludge is admitted to the conveyor-mixer, E, at F.

There it comes in contact with coke particles which are at a temperature between 450 and 650 F. The sludge is mixed with the hot coke and immediately begins to decompose. The gas evolved from this decomposition flows out through the outlets, G.

The coke produced mixes with the circulating coke and proceeds on its path through the retort. The movement of coke and sludge in the conveyor-mixer is due to the rotation of two ribbon conveyors which are set sufficiently close together so that the flights of one revolve in the free space of the other. This arrangement provides for thorough mixing of the coke and fresh sludge during the time that they are being transported to the rotor lift, D.

The coke-sludge mixture is fed by gravity to this rotor lift and is then transported vertically upward to the top of the retort. There, a horizontal conveyor carries the mixture to heat exchanger, B. This heat exchanger is provided with 52 tubes which are hung freely from a tube sheet near the top of the exchanger shell. The coke flows down through these tubes and, as it does so, it is heated by hot furnace gases circulating outside of the tubes.

The coke falling from the tubes impinges on a conical baffle, X, whose purpose is to insure even flow through all of the tubes of the exchanger. When the coke passes this cone, it enters the conveyor-mixer and there comes in contact with fresh sludge. Thus the cycle begins again.

The excess coke which is produced by the decomposition of the sludge is removed at H, immediately above the heat exchanger tubes. This coke is conveyed by a screw to a coke storage tank, K. From there, it is transported by means of a belt conveyor, M, to a storage bin, N, used for loading railroad hopper cars. The excess coke as produced is hot. In order to prevent its ignition, it must be stored initially in the absence of air.

Therefore, the coke storage tank is air-tight. When the coke leaves the storage tank, it is cooled by a stream of water which flows over it as it comes onto the belt conveyor, used for transportation to the bin. This water-cooling brings the coke temperature down to around 200 F. and the water is allowed to remain on the coke during storage in the bin and subsequent shipment to points of use.

Interesting Feature—An interesting feature of the retort is the way in which the heat exchanger is constructed. The tubes are suspended from a sheet at the top, but there is no tube sheet at the bottom of the exchanger. Consequently, the furnace gases used for heating the coke circulate around the tubes and have free access to the coke itself at the bottom of the tubes.

These combustion gases can not contaminate the sulfur dioxide obtained from the sludge because the flowing coke leaving the bottom of the heat exchanger acts as a seal preventing the gases from the exchanger from getting into and beyond the conveyor-mixer where the sulfur dioxide is evolved. A supplementary method of heating the coke before it enters the conveyor-mixer is provided by the admission of hot air to the lower part of the heat exchanger through pipe, A. This air, coming in contact with the hot coke there, causes combustion to take place and raises the temperature of the coke particles.

As a result of the heating in the exchanger tubes and of the combustion with air, the coke particles leaving the heat exchanger have a temperature between 450 and 650 F. The surface temperature of the coke particles is, moreover, higher and considerable cracking of adsorbed hydrocarbons takes place in the heat exchanger.

The cracked hydrocarbons, as well as much of the natural volatile matter in the coke, distill off at this point in the retort, leaving the coke that goes into the conveyor-mixer low in volatile content and ready to adsorb the fresh sludge as it is admitted.

The hydrocarbons evolved from the coke in the heat exchanger mix with the gases coming from the retort furnace as well as the gases which arise from the partial combustion of the coke. Part of this mixture of gases is then fed back to the furnace where additional fuel and air are introduced,

TABLE 2
Comparative Gas Analyses

	RETORT GAS		Gas From Sulfur Burning
	Before Purification	Ready for Conversion	
Percent SO_2	65	8	9
Percent O_2	1	11	12
Percent N_2	0	75	79
Percent CO_2	9	6	
Percent Hydrocarbons	25		
	100	100	100

TABLE 3
Analysis of Coke From Prototype Sludge

Percent Fixed Carbon	70
Percent Volatile	29
Percent Acid	1
Total	100
Screen Analysis:	
Percent Retained on No. 5	0.3
10	26.9
20	67.9
30	4.1
40	0.4
60	0.2
80	0.1
Percent Dust	0.1
Total	100.0

when needed, to maintain the furnace exit gas at about 1400 F. Not all of the gas leaving the heat exchanger can be fed to the furnace and the excess is bled off to a fume furnace, FF, where it is burnt in conjunction with natural gas. (The heat generated in this fume furnace is, in turn, used to heat the air which is admitted to the retort furnace and to the lower part of the heat exchanger.) The gases leaving the fume furnace are low in sulfur dioxide and in hydrocarbons.

Heat Input—The heat input for the retort depends on the type of sludge being processed. When the prototype sludge is being run, approximately 500 Btu's are required per pound of sludge. This Btu input is high enough to maintain all temperatures within the retort above the decomposition point of the sludge feed. The highest temperature is, of course, at the coke exit of the heat exchanger.

The coke entering the conveyor-mixer must be sufficiently hot to furnish practically all of the Btu's required to decompose the sludge which is admixed with it. Thus the coke leaving the exchanger has a temperature between 450 and 650 F.

The introduction of sludge in the conveyor-mixer reduces the coke temperature so that the coke entering the bottom of the rotor lift has a temperature of between 400-500 F.

The rotor lift is jacketed and hot combustion gases pass within the jacket, I, in order to maintain the temperature of the coke while it is being elevated. The horizontal conveyor, C, carrying the coke from the rotor lift to the top of the heat exchanger is well insulated to prevent heat losses.

Thus the coke enters the heat exchanger tubes at approximately its exit temperature from the conveyor-mixer. As the coke drops through the heat exchanger tubes its temperature begins to rise again.

The volume of coke is large in relation to the volume of sludge. As much as 30 tons of coke may be circulated with each ton of sludge. This high coke-to-sludge ratio results in a smooth and easy decomposition of the sludge.

Furthermore, the fact that so much coke is used levels out temperature differences within the retort so that thermal strains are kept at a minimum. Because of the evolution of sulfur dioxide a slight pressure is developed within the retort.

This amounts to approximately one-fourth-inch of water at the upper and lower sulfur dioxide outlets, G. Since the gas exit pressure is low, the pipe into which the gas flows should be slightly below atmospheric pressure. It has been found best to keep it at a vacuum of one-half-inch of water.

The retort now in operation has a capacity corresponding to 50 tons of the prototype sludge per day. Approximately 95 percent of the sulfur dioxide content of the sludge is recovered in the retort. The coke yield, of course, varies with the nature of the hydrocarbons in the sludge. When the prototype sludge is used as a feed, each 50 tons of sludge yield about 14 tons of coke.

The retort is constructed of plain steel with the exception of the heat exchanger which is made of stainless steel. The only severe corrosion takes place in the conveyor-mixer near where the sludge enters: a portion of the ribbons on the screws there has a tendency to wear out every 4 to 6 months. Since the corrosion is localized, however, repair of the ribbon is a simple matter usually requiring only two days' downtime.

The retort's space requirements are modest. A unit capable of processing 50 tons of sludge per day occupies the space shown in Table 4.

Very little additional space will be needed for a 75-ton unit now under construction. In mild climates, no housing for the unit is necessary but some protection from the weather is advisable where winters are severe. The approximate cost of the retort is about $1000 per ton of sludge feed daily capacity. Thus, a 50 ton unit would cost about $50,000, exclusive of license fee.

The operation of the retort is largely automatic. One man can supervise the actual running of from one to three retorts. His duties consist merely of recording temperatures, adjusting sludge feed, and general supervision.

The process and the retort are covered by pending applications for patents, and are available on license to other companies interested in the conversion of acid sludge. Several installations are now in the construction or planning stage. ##

TABLE 4
Space Requirement of Retort

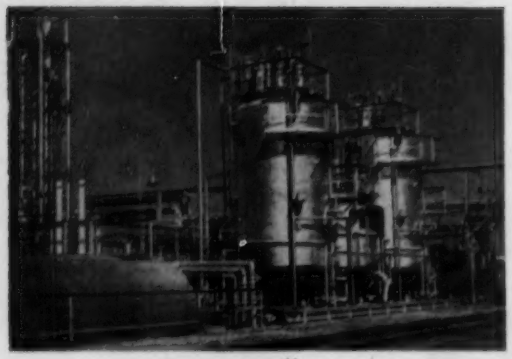
	Width	Length	Height
Actual Size, Feet	6	15	28
Size with Working Space, Feet	15	35	28

About the Author

G. HUNTER MILEY, a 1920 graduate of Virginia Polytechnic Institute,

was with Chemical Construction Corporation several years in the development, erection and operation of heavy chemical plants before he joined L. Sonneborn Sons, Inc., in 1936. His experience included participation in the development of the first commercial acid-sludge-recovery plant. The installation was built for the Sonneborn organization at Petrolia, Pa., in 1932, and Miley later joined the Daugherty Refinery, a Sonneborn division, as manager of the Petrolia acid-recovery plant and Power division.

PROCESS ISSUE '55
18th Annual



FIRST DUALAYER TREATER FOR FUEL OIL

At Magnolia's Beaumont refinery, treated distillates have excellent stability in storage, as evidenced by their good color and low sediment content.

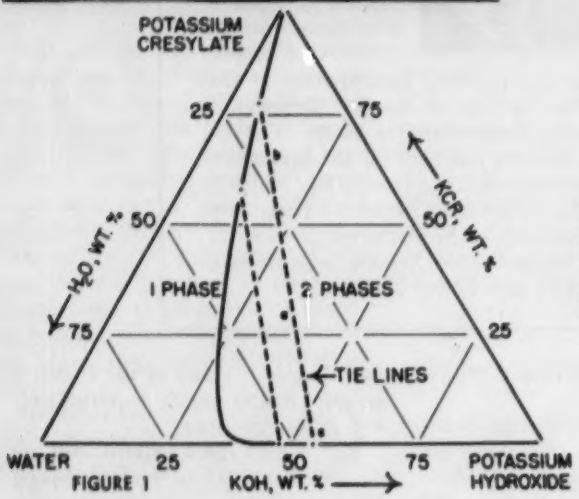


FIGURE 1

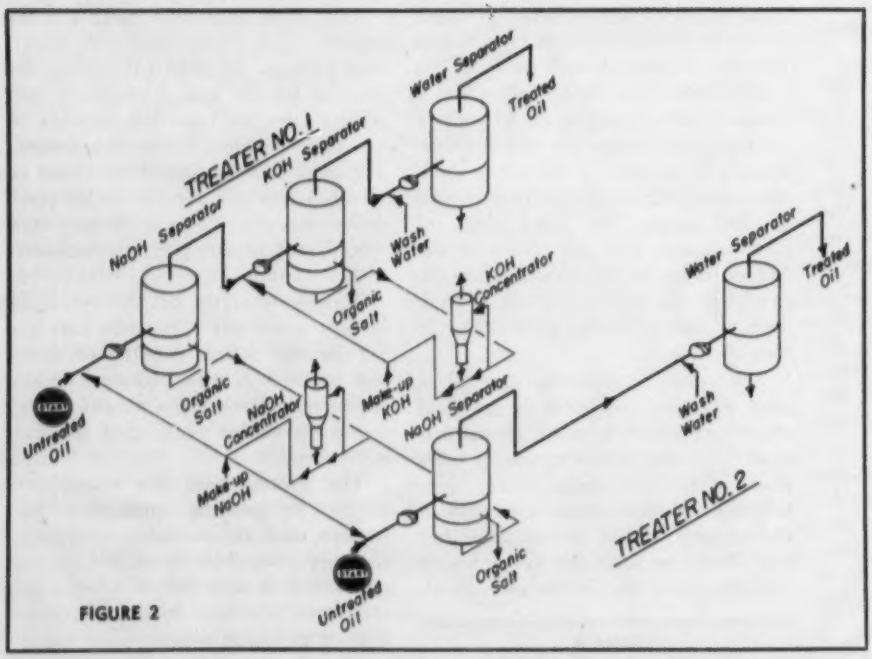


FIGURE 2

C. A. Duval
R. T. Malin
V. A. Kalichevsky
Magnolia Petroleum Company, Beaumont

Photo shows Dualayer process installation; in operation since November 1, 1954. FIGURE 1 (middle) is phase diagram for KOH-KCR-H_2O. These are the conditions necessary for the formation of three layers. FIGURE 2 is the flow diagram for the process. The two treaters have some auxiliary equipment in common.

A 30,000-BARREL-per-day Dualayer distillate fuel oil treating unit was placed into operation at the Beaumont refinery of Magnolia Petroleum Company on November 1, 1954. It is the first unit to employ the Dualayer principle in the treatment of distillate fuel oils with sodium and potassium hydroxide solutions. The treated distillates have excellent stability in storage, as evidenced by their good color and low sediment content. The carbon residue content is also reduced and the treated cracked products are compatible with straight-run distillates having poor carbon residue blending characteristics. The odor is improved by the removal of mercaptans and oxygenated compounds. Inexpensive installation, modern instrumentation and small consumption of chemicals result in low treating costs. One man is ample to operate the unit.

Theory of the Fuel Oil Dualyer Process—The theoretical principles involved in the Dulayer process were described in an earlier article.[1] Important facts concerning refining of cracked fuel oil distillates by the Dualayer process are summarized as follows:

1. Instability of cracked distillates in storage is due to the presence of acidic compounds like certain mercaptans and phenolic compounds. These harmful substances are removed by Dualayer refining.

2. Strong alkali solutions are necessary for efficient extraction of these accelerators of undesirable oxidation reactions. Potassium hydroxide is more efficient in this respect than sodium hydroxide but more expensive.

3. The 40-percent by weight sodium hydroxide and 50-percent by weight potassium hydroxide solutions are the preferred treating agents. Oils which must be refined with potassium hydroxide are pretreated with sodium hydroxide for economic reasons.

4. The strong alkali solutions used in the Dualayer process form three immiscible layers when mixed with the oil. The top layer is the refined oil. The middle layer contains the extracted harmful compounds in alkali solution and is called the "salt layer." The lower layer is the unreacted alkali solution which is recycled in the process. Recycling permits complete utilization of alkalies in the extraction operation.

Conditions necessary for the formation of three layers in the Dualayer process are shown in Figure 1. The triangular phase diagram refers to a system containing potassium hydroxide, potassium salts formed with the acidic oil constituents referred to for simplicity as "potassium cresylate," and water. The tie line *a* on the diagram shows the composition of the layers which separate in the two-phase region. In the example shown on the diagram these compositions are represented by points *b* and *c*. The layer *b* contains the extracted salts and the layer *c* is free potassium hydroxide solution which can absorb additional quantities of acidic substances from the oil. In the Dualayer process the strength of the treating solution is controlled so as to permit continuous withdrawal of the salt layer without contaminating the potassium hydroxide solution recycled to the unit.

Dualayer Treaters—The Dualayer unit installed at Beaumont consists of two separate treating systems having some of the auxiliary equipment in common. Each treater has a capacity of 15,000 barrels per stream day. Treater No. 1 uses both sodium hydroxide and potassium hydroxide solutions and Treater No. 2 uses only the sodium hydroxide solution. Fuel oil distillates produced by the refinery are divided between the two treaters according to their treating characteristics. Distillates difficult to treat, such as those originating from certain West Texas crude oils, are charged to Treater No. 1 while the rest of the distillates are handled by Treater No. 2. Operating conditions are shown in Table 1.

TABLE 1

Typical Operating Conditions on Treaters Nos. 1 and 2

UNIT	No. 1	No. 2
Oil Rate, B/D	15,000	15,000
Temperature Inlet Oil, °F	130	130
NaOH Treat		
Dosage, Volume Percent Oil	5	5
Mixer Pressure Drop, psi	25	25
Solution Strength, Wt. % NaOH	40	40
KOH Treat		
Dosage, Volume Percent Oil	5	....
Mixer Pressure Drop, psi	25	....
Solution Strength, Wt. % KOH	50	....
Water Wash		
Dosage, Volume Percent Oil	10	10
Mixer Pressure Drop, psi	20	20
CONCENTRATORS		
Unit	NaOH	KOH
Charge Rate, B/D	185	100
Temperature, °F	165	145
Pressure, In.Hg Abs	27	27
Solution Strength, Weight Percent		
Inlet	40.0	50.0
Outlet	41.5	50.4

The fuel oil entering the treater is mixed with 5 percent by volume of alkali solution at 130 F. A mixing valve is used for obtaining a thorough dispersion of the reagent. The resulting emulsion passes into the separator equipped with electrical precipitators for reducing the settling time and obtaining a sharp separation between the three layers: the treated oil, the salt layer, and the free caustic solution. These layers are withdrawn from the separators in individual streams. The oil from the treating stages contains as little as 0.001-0.004 percent by weight of alkalies as compared to 0.08-0.16 percent of alkalies which would be obtained by gravity settling in the absence of the electrical precipitators.

Consumption of the alkalies is directly related to the quantity of acidic substances extracted from the oil. Sodium hydroxide consumption varies from 0.20 to 0.30 pound per barrel and that of potassium hydroxide from 0.06 to 0.08 pound per barrel of treated oil. Acidic compounds extracted by the alkalies represent from 0.2 to 0.4 percent of the oil charge and the product yield is over 99 percent by volume.

Water is formed in the reaction between alkali hydroxide solutions and the acidic substances in the oil. Some water is introduced into the unit with the charge stock. The quantities of water are small but they must be removed from the system in order to maintain concentrations of the alkali solutions at working levels. Weak solutions have a low extraction power and interfere with the separation of the salt layer. Water is removed from the recycled treating solutions by distillation. Two concentrators are used for this purpose—one of the sodium hydroxide solution, the other for the potassium hydroxide solution. Diameters of these concentrators are only 2½ and 1 foot, respectively, but their capacity is in excess of the requirements and will be fully utilized when the Dualayer treating facilities are expanded. A small portion, about

PROCESS ISSUE '55
18th Annual

100-200 barrels per day, of the alkali solutions is passed through the concentrators which are controlled automatically. The strength of the alkali solutions is regulated by adjustments in the steam supply to the heating coils. The duty of the operator is reduced to occasional testing of the gravities of the caustic solutions.

Before the treated oil leaves the system it is washed with ten percent by volume of water for removing the last traces of alkalies. Water and oil are passed through a mixing valve and, as in the caustic treating stages, separation is speeded up by the use of electrical precipitators.

Product Quality—Properties of a typical untreated fuel oil distillate processed through the Dualayer unit are shown in Table 2. Properties of the treated product, including its blending characteristics with a sweetened West Texas distillate, are shown in Table 3. Color and sediment stability of the oil were determined by moderately accelerated tests equivalent to one or two years of tank storage depending upon climatic conditions.

The tabulated data show that Dualayer treatment reduced the rate of sediment formation from 17.3 to 2.5 mgs. per 100 ml. In addition, the treated product has an excellent response to inhibitors. If further improvement in the oil stability is desirable, a small quantity of standard inhibitors reduces the sediment formation to below 1 mg. per 100 ml.

TABLE 2
Properties of Untreated Cracked Fuel Oil Distillate

Gravity, °API	28.3
Color, ASTM	1½
Pour Point, °F	5
Flash Point, (COC), °F	198
Sulfur Content, Weight Percent	1.1
Mercaptan Sulfur, Weight Percent	0.022
Carbon Residue (on 10% bottoms), Wt. %	0.10
ASTM Distillation, °F.:	
I.B.P.	426
10 percent	486
50 percent	536
90 percent	610
E.P.	660
Recovery, Volume percent	98

TABLE 3
Dualayer Treated Cracked Fuel Oil Distillate

	Untreated	Treated
Properties		
Gravity, °API	28.3	28.3
Color, ASTM	1½	1½
Mercaptan Sulfur, Wt. percent	0.022	0.001
Carbon Residue (on 10% bottoms), Wt., percent	0.10	0.07
Carbon Residue Blending Value[1] (on 10% bottoms), Wt. percent	0.27	0.07
After One Year Storage Equivalent[2]		
Carbon Residue, Wt. percent	0.49	0.21
Color, ASTM	>8	4
Sediment, mgs./100 ml.	17.3	2.5

[1] Blended with 25 percent by volume of sweetened 550° F. E. P. West Texas straight-run kerosine having a 0.04 C.C.R. on 10 percent bottoms.

[2] Based on Gulf Coast temperatures. Equivalent to two years storage on East Coast.

Fuel oil distillates are higher boiling than gasoline and contain mercaptans which are difficult to extract. The data show that the mercaptan content of the oil most resistant to mercapan removal was lowered from 0.022 to 0.001 percent by weight. The mercaptan content of other fuel oils was reduced beyond the sensitivity of the doctor test.

The Conradson carbon residue of the untreated distillate was 0.10 weight percent on the ten percent bottoms. However, the blending value of the residue in mixtures with sweetened West Texas distillate was 0.27 weight percent. This is explained by the interaction between the converted sulfur compounds in the virgin stock and the unstable components of the cracked stock.[2] The Dualayer treated distillates show no deviations in their carbon residue blending values. Apparently substances contributing to this incompatibility are acidic compounds extracted by the strong caustic solutions.

Meet the Authors

Kalichevsky Malin Duval

VLADIMIR A. KALICHEVSKY is author writer widely-known in the refining industry. Author of many articles on petroleum and a contributor to the REFINER since 1944, his published works include three books on refining. Kalichevsky joined Union Oil Company of California in 1924, after completing an engineering degree at California Institute of Technology. After some years as a research chemist with that company and a similar position with Standard Oil Development Company, he became a section leader in the Research & Development department of Socony-Vacuum Oil Company, Inc., and in 1937 was named general supervisor of the department. Since 1944, he has been consulting chemical engineer with Magnolia. Kalichevsky was born in Russia and educated in the Corps of Pages of the Imperial Russian Court and the General Staff's College at Petrograd. During World War I, he served as a captain in the Imperial Guards and later fought the Bolshevists in Siberia.

RUFUS T. MALIN, with the Technical department at Magnolia Petroleum Company's Beaumont refinery for the past 16 years, was working on a master's degree in electrical engineering at the University of Texas when he joined the company in 1939. Since then his processing experience has included all phases of lubricating-oil and light-oil refining. In 1946 he was promoted to supervisor of the department's lubricating oil distillation and solvent-treating activities; two years later he was named to a similar position covering catalytic and thermal cracking, and in 1949 he became assistant chief process engineer. Since 1951 he has been head of the refinery's process control laboratories.

CLAIBORNE A. DUVAL, JR., in charge of light oils in the process control laboratories at Magnolia Petroleum Company's Beaumont, Texas, refinery, is familiar as a writer to many PETROLEUM REFINER readers, having contributed articles off and on since 1951. A chemical engineering graduate from the University of Texas, he joined Magnolia in 1941 as a chemist in the analytical laboratory. Before taking his present assignment, Duval worked two years in process control and served six years as a process engineer on Houdry and TCC units.

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[2] R. C. Morbeck, "Hydrofining of Middle Distillates," O&GJ, January 3, 1955, p. 94.

Three units are being designed now; Aurora Gasoline Company's unit at Detroit probably will be the first completed.

REXFORMING Looks to First Unit

William K. Hunter,
Universal Oil Products Company,
Des Plains, Ill.

THE REXFORMING process developed by Universal Oil Products Company provides a versatile tool to produce premium fuels of any potentially useful octane rating required in the ever increasing gasoline quality market. Rexforming combines in recycle operation the flexibility of the Platforming process with selective solvent extraction technique to efficiently produce super-octane gasolines utilizing even the lowest quality feed stocks.

Description of Process—Typical flow arrangment adapting Rexforming for processing of full boiling range gasoline is shown in the process diagram of Figure 1. The charge material is introduced to a reboiled prefractionator which removes light gasoline and heavy bottoms to provide a sidecut fraction as combined feed to the reaction section. The reaction section is similar to and utilizes the catalyst of the Platforming process. Briefly, the reaction section charge material is combined with a recirculated hydrogen-rich gas stream, preheated and introduced into a reactor chain. The effluent streams from the initial and intermediate reactors are reheated before introduction to subsequent reactors. The effluent from the final reactor after heat exchange and cooling enters a separator where the recirculated and net hydrogen-rich gas production are removed. The separator liquid is charged to a stabilization column which functions as a debutanizer.

The debutanized Platformate is continuously charged to the extractor wherein a controlled separation is effected between the lowest and highest octane components. Aromatic and lower boiling (highest octane) non-aromatic compounds exhibiting greater solubility are selectively extracted from the Platformate and removed from the column in rich solvent. The less soluble higher boiling non-aromatic compounds, or lowest octane components, are continuously rejected from the top of the extractor, returned as recycle and mixed with fresh charge stock.

Rich solvent removed from the extractor bottom is continuously charged to a stripper wherein the Rexformate gasoline is separated and removed to storage. The stripped lean solvent is withdrawn and returned to the extractor completing the solvent cycle.

Considerations in Super Fuel Production—Catalytic Reforming upgrades straight run naphthas through four principal reactions: Dehydrogenation of naphthenes, isomerization, hydrocracking, and dehydrocyclization of paraffins.

Net aromatics present in reformates usually represent the products of essentially complete naphthene dehydrogenation and some paraffin dehydrocyclization. Aromatic production from paraffins and a lesser extent from naphthenes involves volumetric loss due to hydrogen production and density change. The volumetric loss is partially offset by excellent octane quality of the aromatics.

Isomerization and hydrocracking are important reactions for upgrading paraffins. Isomerization is the fastest of the paraffin reactions, but is limited in usefulness at the elevated octane levels due to the presence of large concentrations of low-octane paraffins in the equilibrium mixture. Hydrocracking of heavy paraffins is a substantial contributor to octane improvement in naphtha reforming and in part counterbalances the volumetric losses obtained in other reforming reactions.

Production of reformates in the high octane ranges with once-through technique requires high severity operating conditions with the common feed stocks. Increased operation severity effects octane-improvement on the non-aromatic constituents by selective elimination of heavy paraffins through dehydrocyclization to aromatics and hydrocracking to lower molecular weight or higher quality paraffins. Dehydrocyclization of heavy paraffins is severely limited in single pass technique by increased aromatic concentration. Hydrocracking of paraffins is limited by the product volatility specifications and requires a proper balance with the

Meet the Author

WILLIAM K. HUNTER has been with Universal Oil Products Company since his graduation from Colorado School of Mines in 1947. He joined the company as a chemical engineer, and since then has been concerned with construction, operation and development of commercial refining and chemical processes. He now is a member of Universal's Engineering Research and Development department.

PROCESS ISSUE '55
18th Annual

Rexforming Looks To First Unit . . .

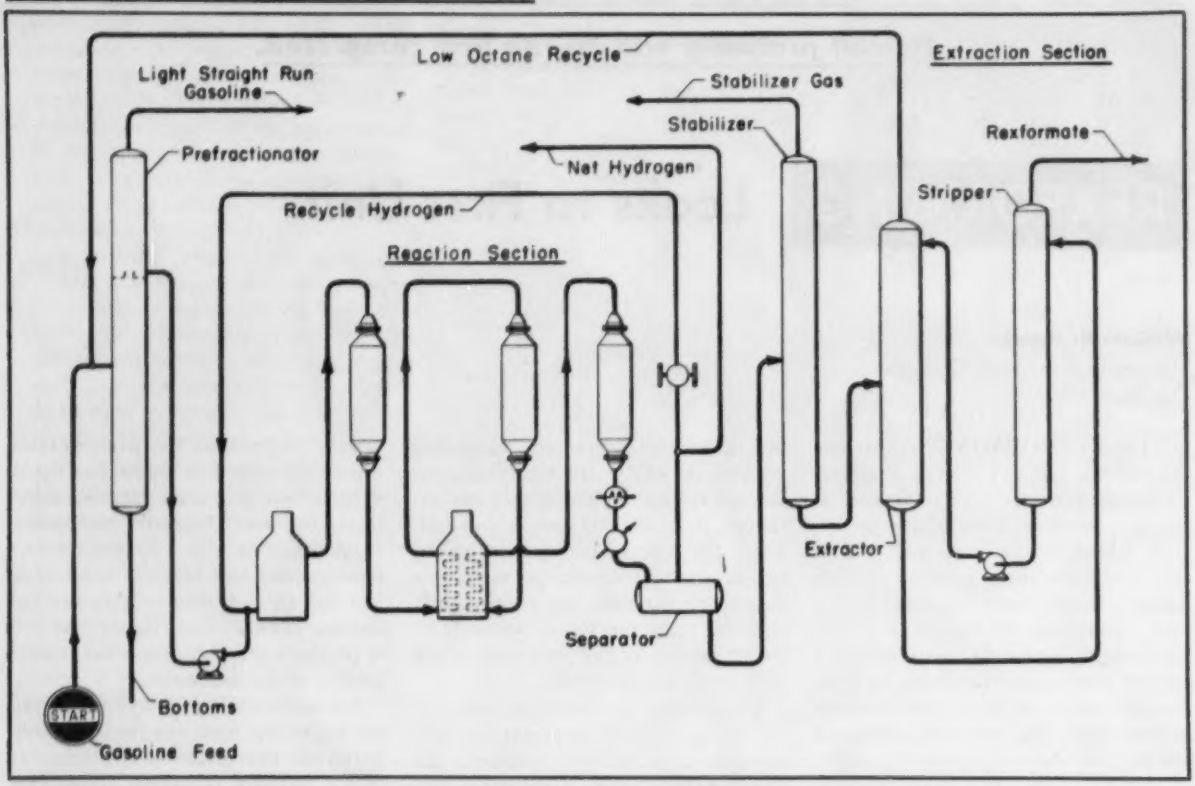


FIGURE 1—Rexforming flow diagram: Units can readily be designed to incorporate Platforming equipment.

other reforming reactions. The above factors constitute a real limitation to the production of super-octane fuels in once-through technique resulting from the presence of small but very important concentrations of low octane paraffins.

The octane limitations imposed by low quality paraffins can be partially offset through increased aromatic concentration. Increased aromatic production may be achieved utilizing lower reaction pressures; however, this increase is accompanied by correspondingly lower paraffin octane quality. Typical comparative data for processing of Mid-Continent naphthas is shown in Figure 2. The graphical comparison indicates the increased percentage of aromatics required at a given reformate octane level at lower pressure processing conditions. Some automotive engine pre-ignition difficulties are considered to be assocated with excessive aromatic concentrations in motor fuels. With this consideration, the minimum aromatic requirement at given octane level would be an essential production technique.

Rexforming Technique—Rexforming overcomes the super-octane limitations inherent in once-through processing through the combination of Platforming and solvent extraction technique. The solvent extraction step is controlled at select conditions to effect a sharp separation between the highest and lowest octane portions of the debutanized reactor effluent.

This high degree of separation results from the relatively greater solubility of aromatic and low boiling, high octane paraffin constituents exhibited in the solvent. For example, aromatic solubilities exceed the solubility of corresponding boiling point paraffins by a multiple greater than five at suitably controlled extraction conditions. At these same conditions the paraffins in the 150 F. boiling range exhibit a solubility three times greater than corresponding paraffins in the 400 F. class boiling range. As can be seen with these solubiliy relationships, the highest octane components, principally aromatics and lower boiling paraffins, will be selectively dissolved and withdrawn from the extractor in the rich solvent, while the lowest octane components, principally high boiling paraffins, are

TABLE 1

Pilot Plant Rexforming Data—Mid-Continent Feed Stock

Inspection Data:	Fresh Charge	Rerun Botts	Combined Feed	Stabilized Reactor Effluent	Low Octane Recycle	Debutanized Rexformate
Gravity, °API	52.3	32.1	56.6	51.3	65.2	44.1
F-1 Clear Octane	33.0	....	....	74.0	36.8	97.5
Aromatics, Volume Percent	9	....	....	36.5	4.1	56.1
100 ML Distillation:						
IBP °F	242	426	176	131	142	126
5 Percent	259	430	230	179	197	165
10 Percent	264	432	243	195	209	183
30 Percent	292	440	272	239	246	241
50 Percent	316	....	299	270	265	283
70 Percent	346	....	334	306	298	322
90 Percent	374	....	368	366	348	372
95 Percent	384	....	380	380	368	394
End Point, °F	415	....	404	443	418	435
Quantities, Volumes per 100 Volumes, Net Feed	101.5	1.5	148.6	128.7	48.6	80.1

continuously rejected.

With integrated Platformer operation the lower octane non-aromatics continuously rejected in the extraction step are returned and mixed with fresh charge stock thus achieving selective conversion and upgrading of the heavier paraffins to super fuel quality components. This recycle of low octane non-aromatics further serves to reduce the concentration of aromatics in the Platformer reaction zones creating a more favorable environment for the dehydrocyclization of paraffins to aromatics.

Figure 2 graphically represents a relationship between octane level and aromatics concentration for Platformates from low and high pressure operation as well as Rexformates from moderately selective operation produced with a typical Mid-Continent feed stock. The comparison vividly demonstrates the minimized aromatic requirement of Rexformates at a given octane level and a measure of the degree of up-grading effected in the non-aromatic fraction.

Partial conversion of low octane non-aromatics in each pass through the reactor section permits the mild reaction severity levels typical in recycle operations. Considerable laboratory and pilot plant experience demonstrate severity-product quality relationships distinctly mild in comparison to once-through operation. Platforming catalyst has demonstrated extensive life characteristics in numerous commercial applications at the temperature levels required in Rexforming, thereby, totally eliminating any necessity for consideration of blocked-out regeneration type processing. In avoiding the instabilities inherent in once-through reforming operation at the high severity levels required to produce near super-octane fuels, Rexforming functions

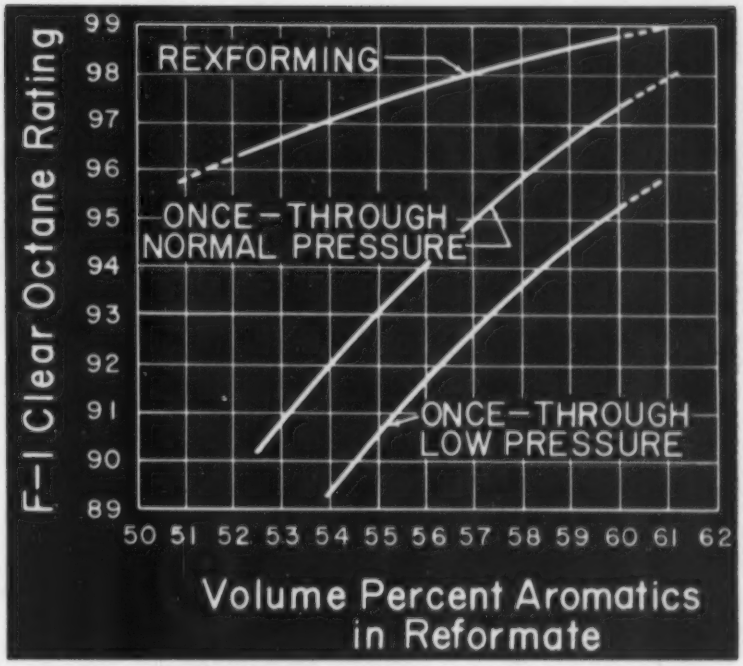


FIGURE 2—Rexformates contain less aromatics for a required octane level.

under more ideal yield producing conditions.

Pilot Plant Data—Summarized in Table 1 are typical test stream and product data selected at mid octane range from pilot plant Rexforming studies on Mid-Continent naphtha. The octane range of the study covered the levels indicated for the reformate aromatic concentration-octane correlation in Figure 2. The reaction temperature averaged more than 20 F. lower than corresponding once-through processing requirements at all octane levels studies, thus providing a clear indication of the reduced severities in recycle operation. The degree of up-grading in the non-aromatic fraction of the product Rexformate is demonstrated by the reduced aromatic concentration required at a given octane level, e.g. approximately 5 percent lower aromatics at the 97.5 octane level. Space velocities utilized in the study were higher in relation to fresh charge stock than would normally be employed for considerably lower product octane levels in once-through reforming.

Examination of the products in Table 1 indicates the low reactor effluent octane number resulting from the mild severity level employed. The low octane level of the recycle material indicates the desirability of further upgrading on this material. The composite properties of the recycle stream indicate the potential of this material for partial or complete withdrawal to serve as a paraffinic solvent or jet fuel component in a refinery specialty product program. The properties of the product Rexformate show the balance of volatility characteristics and the octane level-yield relationship attainable at the processing conditions selected.

Rexforming Economics—Approximations of investment and operating costs are tabulated in Table 2 for producing 98 F-1 clear octane Rexformate in a plant processing 5000 barrels per stream day of full boiling range Mid-Continent straight run gasoline in a flow scheme as outlined in the process description.

Commercial Application—Since Rexforming was announced in March of this year, considerable interest has been demonstrated in the process by the refining industry. Three Rexformers already are in the process of design and construction. The unit for the Detroit refinery of Aurora Gasoline Company will probably be the first commercial unit to operate with completion scheduled for the end of the year.

TABLE 2

Estimated Investment and Operating Costs for Rexforming

Erected Cost (within battery limits)	$1,600,000
Operating Costs:	
¢/barrel full boiling gasoline	
Operating labor at $2.75 per hour	4.0
Laboratory	1.0
Utilities:	
Fuel at 15¢/MM Btu	7.3
Power at 0.8¢/kwh	4.0
Steam at 30¢/M lb	4.6
Water at 1¢/M gallons	1.4
Catalyst	6.9
Solvent	1.7
Maintenance at 3 percent of investment per year. (M & L)	2.8
Insurance and property taxes at 2 percent of investment/year	1.9
Total operating costs excluding royalty, depreciation, administration and overhead	35.6

PROCESS ISSUE '55
18th Annual

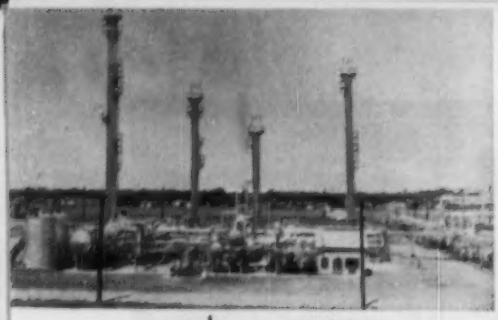
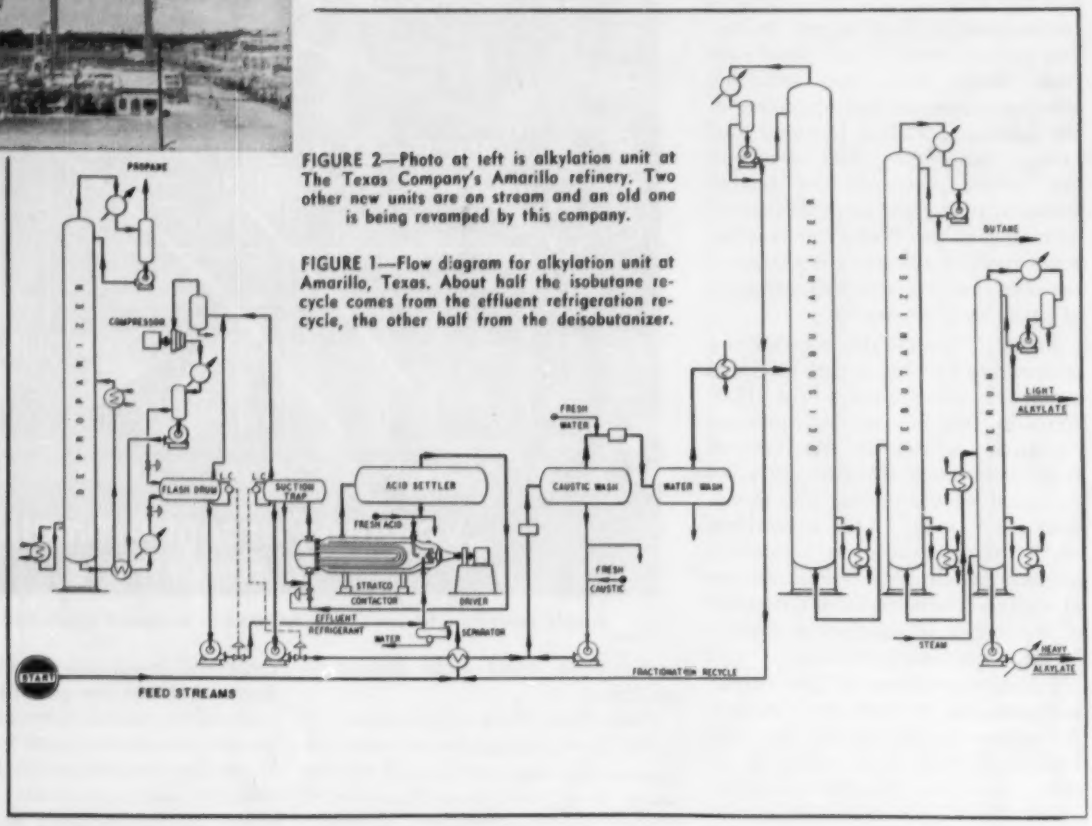


FIGURE 2—Photo at left is alkylation unit at The Texas Company's Amarillo refinery. Two other new units are on stream and an old one is being revamped by this company.

FIGURE 1—Flow diagram for alkylation unit at Amarillo, Texas. About half the isobutane recycle comes from the effluent refrigeration recycle, the other half from the deisobutanizer.



Alkylating with Effluent Refrigeration

First sulfuric acid unit with effluent refrigeration produces 95 (F-1) clear alkylate at low acid consumption.

A. R. Goldsby and D. H. Putney,
Stratford Engineering Corporation,
Kansas City, Mo.

LOWER CAPITAL investment, decreased operating cost, increased yield, higher alkylate quality, and low acid consumption combine to give the Sulfuric Acid Alkylation process unit of The Texas Company at Amarillo, Texas, an unusual commercial interest in a period when refiners are turning to the process for motor fuel production. In addition to investment and operating economies, indications are that the alkylate produced from the sulfuric acid alkylation process will show an octane appreciation when blended with catalytic reformate and catalytically cracked gasoline. The unit went on stream March 4, 1955.

This unit is producing alkylate of high quality with exceptionally low sulfuric acid consumption. It employs "Effluent Refrigeration"[1] which essentially is a means of economically obtaining a very high isobutane concentration in the reaction mixture with little conventional fractionation. Thus the cost of fractionation facilities is greatly reduced. The hydrocarbon effluent from the reactor, after separation in the settler, becomes the refrigerant used in the cooling elements of the reactor, and hence the term "Effluent Refrigeration."

The Amarillo unit was the first one to be designed employing effluent refrigeration and it has given excellent results right from the start. The results obtained and the ease of operation of the unit fully substantiate or surpass the claims and hopes made for the process. The debutanized

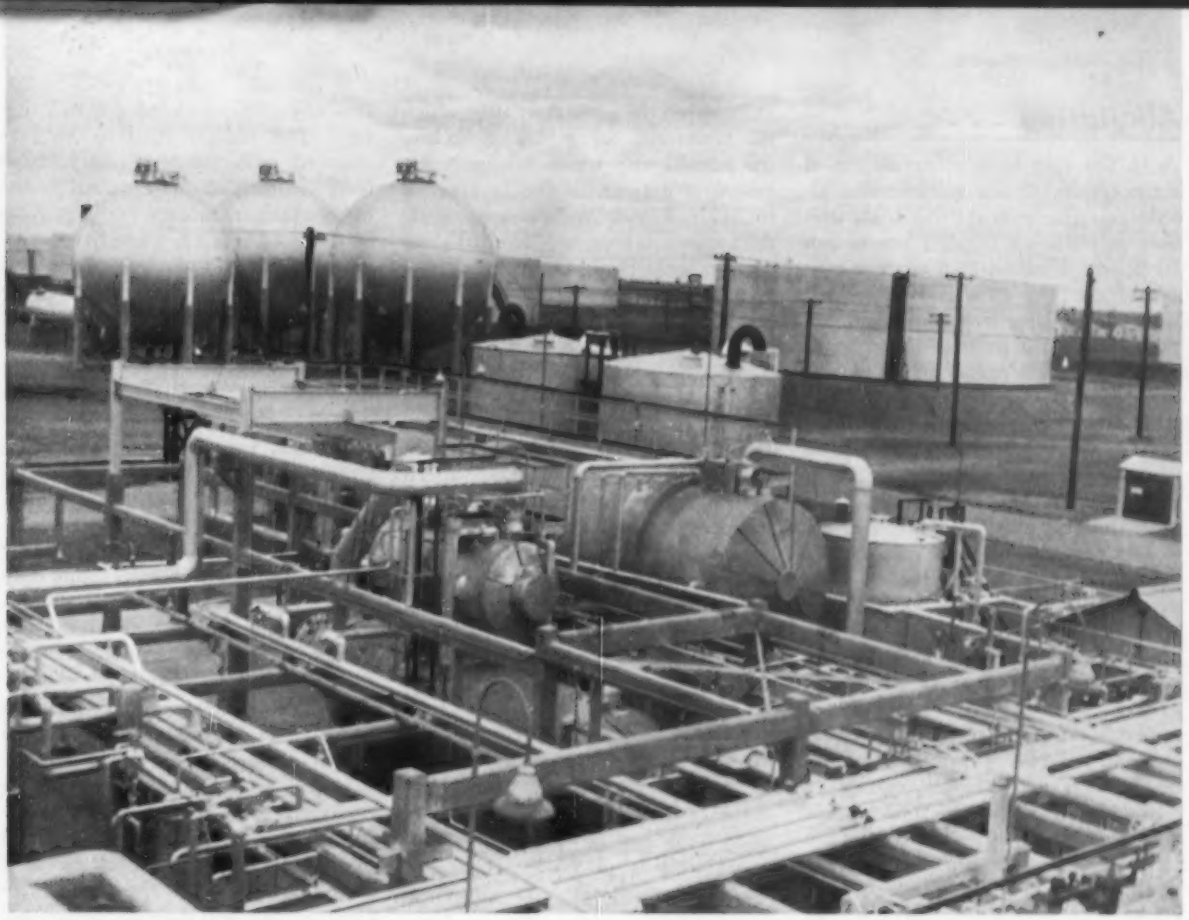


FIGURE 3—View of contactor, suction trap, settler, acid and feed stock storage tanks. Spent acid is sold to a chemical company.

over-all butylene alkylate has an end point of less than 400 F., and the aviation fraction of 95-98 percent has a 3-C Performance Number with 4.6 cc of TEL of 155-160. The catalyst consumption averages less than 0.4 of a pound per gallon of alkylate. The outstanding nature of these results may be more fully appreciated when it is considered that some alkylation units not using effluent refrigeration produce an aviation alkylate having a 3-C Performance Number of only 147 or less, representing only about 90 percent of the total alkylate, and with acid consumption of 0.75 to 1.0 pound of acid or higher per gallon of alkylate.

The detailed design and engineering of this unit were worked out by the engineers of the Refining Department of The Texas Company. The Stratford Engineering Corporation is agent for the Sulfuric Acid Alkylation process and licenses the Effluent Refrigeration process.

Feed Stocks—The Amarillo alkylation unit is part of an over-all expansion program which has resulted in an increase in crude running capacity from about 8500 to 15,000 barrels per day. In addition to the alkylation unit, a new crude unit, two thermal cracking units, fluid catalytic cracking unit, polymerization unit, and Platformer have been installed.

The feed stock for the alkylation unit depends on the operation of all the other units. Usually, the major portion of the olefin charge stock is the over-all butylene fraction from the catalytic cracking unit, and the rest from the thermal cracking units. The olefin charge is treated to remove hydrogen sulfide and mercaptans. The isobutane charge stock, aside from the isobutane contained in the olefin charge stock, is essentially the over-all C_4 fraction from the Platformer. This saturated C_4 fraction is charged directly to the deisobutanizer tower for separation of isobutane from normal butane.

Two 12,000-barrel butylene storage tanks were used for about the first month but since that time only one has been used. Two tanks enable more efficient settling of entrained water. The second tank will again be used in the Fall. A 1000-barrel storage tank is used for excess isobutane from the deisobutanizer tower. Before being introduced into the contactor, the charge stocks are cooled to about 45 F., and any separated water withdrawn.

Up through June the only charge stock which had been alkylated was one in which butylenes predominated. However, propylene and amylenes may be alkylated, and there is every reason to believe that the inherent advantages which are obtained with Effluent Refrigeration on butylenes would hold for propylene and amylenes.

Operation of Unit—The Amarillo unit was designed for 900 barrels per day of debutanized aviation alkylate.

PROCESS ISSUE '55
18th Annual

Alkylating . . .

As is the case with other alkylation units employing the sulfuric acid alkylation process, the Amarillo unit uses as make-up catalyst strong sulfuric acid of about 98.6 percent concentration. The catalyst is circulated until the acidity drops to about 90 percent when a portion of the spent acid is withdrawn and an equivalent amount of new acid added.

The unit has proven to be very easy to operate and easy to keep on stream, despite occasional upset conditions on the other units integrated with the alkylation unit.

The desired minimum volume percentage of acid in the reaction mixture in the contactor is about 45 percent, and a percentage of about 45-47 percent has been easily maintained.

During a shortage of isobutane, such as was experienced during a nine-day shutdown of the Platformer, the unit may be operated for a long period with only the isobutane in the olefin charge stock and that obtainable from the 1000-barrel storage tank. Under such conditions, practically all of the recycle isobutane comes from the flashed refrigerant compressor condensate rather than from the deisobutanizer overhead.

Process Description

Referring to Figure 1, the feed streams are first cooled by heat exchange with cold effluent from the suction trap, followed by intensive mixing with sulfuric acid in the contactor. The temperature in the reaction zone of the contactor is maintained at about 45 F. The acid-hydrocarbon mixture leaving the contactor is passed to the settler where it is separated into an acid phase which is returned to the suction side of the contactor impeller and a hydrocarbon phase which leaves the top of the settler.

A back pressure regulator valve located in the hydrocarbon effluent line from the settler maintains the reactor-settler system at a pressure sufficiently high to hold all components in liquid phase, usually about 40 psig or higher. The hydrocarbon effluent passing the back pressure regulator is reduced in pressure from about 40 psig to about 3 to 5 psig and is thereby self-cooled to about 20 F., by partial vaporization of its isobutane component. The resulting cooled effluent is routed through the cooling coils within the contactor, after which the liquid and vapor pass on up into the suction trap which is usually operated at a pressure also of about 3 to 5 psig. The cooling elements of the contactor are kept flooded with a recycle of cold liquid from the suction trap.

As the exothermic heat of the alkylation reaction is released it is transferred through the walls of the cooling elements to the self-chilled effluent which results in the vaporization of the more volatile components from the effluent. The vapors, which are largely isobutane, are disengaged from the liquid in the suction trap, passed to the compressor and condensed. After depropanization the condensate is sent to the flash drum where cooling to about 18 F. is accomplished by vaporization of a portion of the condensate at compressor suction pressure.

A liquid level control regulates the flow of cold liquid leaving the suction trap. The cold liquid is heat exchanged with the incoming fresh feed, neutralized and passed to the deisobutanizer. Since a major portion of the isobutane has already been removed from the alkylate, the quantity of material which is sent to the deisobutanizer is small compared to that in an alkylation system without effluent refrigeration. The overhead from the deisobutanizer and the isobutane obtained from the effluent refrigeration recycle (bottom stream from flash drum) constitute the total isobutane recycle to the reaction zone. Of the total isobutane recycle usually 50 percent or more is supplied by the effluent refrigeration recycle and only 50 percent or less by the deisobutanizer. At times almost all of the isobutane recycle has been supplied by the Effluent Refrigeration cycle.

The debutanization and the fractionation of the alkylate are carried out in a conventional manner.

It will be noted that in the effluent refrigeration system described, although the refrigeration is obtained by vaporization of isobutane, none of the isobutane is allowed to vaporize from the reaction mass in the contactor. Thus the total amount of isobutane from the effluent refrigeration recycle is present in liquid phase throughout the entire reaction zone and contributes to increasing the concentration of isobutane in the same manner as though it had come from a deisobutanizer. Yield and quality of alkylate are increased, and acid consumption is decreased, accordingly.

Addition of Fresh Acid—In order to take advantage of the known fact that alkylate of higher quality may be made with increasing acidity in the range of about 90 to 96 percent, a modified batch operation of the acid is used since there is only one contactor. When the acid in the system reaches the level selected for discharge, which is usually 90 percent, approximately one-third of the acid in the system is withdrawn, and then an amount of fresh white acid, usually of about 98.6 percent concentration, approximately equal to that withdrawn is charged. The operation is repeated when the acidity again reaches 90 percent. On this particular unit, the time between additions of fresh acid is usually in the range of 4 to 7 days, depending on the op-

TABLE 1

	June 10, 1955	June 28, 1955
Operating Conditions:		
Temp., F.	42	45
Isobutane in reaction mixture	71.5	65.5
Conc. of system acid, weight percent	90.1	92.0
Feed Stock	Butylenes	Butylenes
Percent acid by volume in reaction mixture	45	47
Rate of production i: bpd	775	830
Space velocity (GPH olefin/gallon acid i: reactor)	0.39	0.40
Total Debutanized Alkylate:		
IBP	116	112
10 percent	170	164
20 percent	188	184
50 percent	216	214
90 percent	257	252
EP	382	381
Rec.	98.7	98.5
Loss	0.7	0.6
Res.	0.6	0.9
RVP	3.3	4.2
CFRR (F.1) clear	95.6	94.3
CFRR 3 cc TEL	Isooctane+ 0.88 cc TEL	Isooctane+ 0.60 cc TEL
1C Performance No. 4.6 cc TEL	122.8	121.8
3C Performance No. 4.6 cc TEL (Supercharged F-4)	157.8	154.8
Aviation Alkylate:		
Percent of Total Alkylate	95.4	94.3
IBP	113	118
10 percent	162	166
20 percent	180	183
50 percent	213	212
90 percent	234	229
EP	314	298
Rec.	98.0	99.0
Loss	1.5	0.7
Res.	0.5	0.3
RVP	4.3	4.1
CFRR (F-1) clear	95.9	94.8
CFRR 3 cc TEL	Isooctane+ 0.97 cc TEL	Isooctane+ 0.84 cc TEL
1C Performance No. 4.6 cc TEL	125.7	124.2
3C Performance No. 4.6 cc TEL (Supercharged F-4)	159.5	155.5
Heavy Alkylate or Bottoms:		
Percent of total alkylate	4.6	5.7
IBP	.....	345
10 percent	.....	352
20 percent	.....	354
50 percent	.....	359
90 percent	.....	400
EP	.....	486
Rec.	.....	98.0
Res.	.....	1.1
Loss	.....	0.9
RVP	.....	0.0
CFRR clear	.....	84.3
CFRR 3 cc TEL	.....	97.3
3C Performance No. 4.6 cc TEL	.....	109.6

erating conditions, composition of the charge stock and rate of production of alkylate.

Catalyst Consumption—From experience obtained to date on the Amarillo unit, it appears that the acid consumption under normal conditions of operation should not exceed about 0.3 pound per gallon of alkylate.

The consumption of fresh sulfuric acid catalyst of about 98.6 percent concentration from the start-up of the unit on March 4, 1955 through July 6, 1955, has been 1 volume of acid per 40.1 volumes of total alkylate, or 0.384 pound of acid per gallon of alkylate. This includes the initial inventory of acid, and all acid added to the unit. Operations were at times conducted under conditions which varied abnormally due to problems inherent in the initial coordination of alkylation with other refinery processes. Some of these variations have resulted in comparatively rapid loss in acid strength over short periods.

During the period of approximately five weeks from March 14 through April 17, the acid consumption was 1 volume of acid per 60.6 volumes of alkylate, or 0.254 pound of acid per gallon of alkylate.

Disposal of Spent Acid—With the low acid consumption being experienced, the amount of spent acid is small; hence its disposal is not a great problem. It is sold under contract to a chemical company, and it is understood that it is used in the manufacture of fertilizer.

Contactor—There is a single small size heat exchange contactor used in this alkylation unit, having a net operating volumetric capacity of 4500 gallons, and a heat exchanger surface of 4160 square feet. Under the conditions of operation the internal circulation rate is about 25,000 gpm and the over-all heat transfer rate is above 60. This contactor has a nominal rating for the production of alkylate up to about 1000 or 1100 barrels per day.

Discussion of Results

The two sets of data reported in Table 1 reflect typical operating results.

The low end point of around 380 F., for the total debutanized alkylate, its clear CFRR octane value of about 95.0 and its CFRR octane value with 3 cc of lead equal to isooctane plus about 0.6 to 0.9 cc of lead explain much of the current interest in sulfuric acid alkylate for premium automotive fuel. In this same connection it will be noted that the heavy alkylate or undistilled bottoms above the aviation fraction has a clear CFRR octane value of 84.3 and a value of 97.3 with 3 cc of lead.

The percentages of the low end point aviation alkylate reported in the table and expressed in terms of the total debutanized alkylate are 95.4 and 94.3, respectively, for the 314 and 298 F. E.P. samples. The percentage of 338 F. E.P. aviation alkylate would be in the range of 96-98 percent.

The reason for the difference in the quality of the two samples of alkylate is explained in part by the higher percentage of isobutane in the reaction mixture for the June 10 sample, although the quality of both samples is at the normally high level.

On May 17 when the production of alkylate was more than 1000 barrels per day and the space velocity was about 0.50 because of excess olefin feed stock being available, complete data are not available. However, the distillation data for the aviation alkylate and bottoms are quite similar to those in Table 1, and the 3-C Performance number of the aviation alkylate was 157.2.

Commercial Installations

Since effluent refrigeration results in decreased investment and operating costs for an alkylation unit, and makes it economically attractive to use favorable alkylation conditions for the production of high quality alkylate with low acid consumption, there is a growing commercial interest in the process. Also, for these same reasons, and the fact that alkylate with an end point well below 400 F., may be made, there is as much or more interest in the process for motor fuel production as for aviation gasoline.

In addition to the Amarillo unit, The Texas Company has two other new and larger units using effluent refrigeration, which went on stream after the Amarillo unit, and one old unit which has been revamped to obtain the advantages of effluent refrigeration.

Several other plants are now either under construction or are in the final design stage, and a considerable number of other new and revamp jobs are being planned.

ACKNOWLEDGMENT

The authors wish to express their sincere thanks and appreciation to Texaco Development Corporation and The Texas Company for permission to publish this article, and also for their cooperation and help in the preparation of the data. The esprit de corps and pride of all those concerned with the operation of the unit are noteworthy.

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Meet the Authors

Goldsby

Putney

A. R. GOLDSBY recently was appointed director of research with Stratford Engineering Corporation. With The Texas Company and its Texaco Development Company since 1936. Dr. Goldsby also has been associated with National Aluminate Corporation and National Aniline Division of Allied Chemical & Dye Corporation. With the Texaco organization, he was concerned with the research and development of the sulfuric-acid alkylation process, and while with National Aniline, figured prominently in the early development of synthetic detergents.

D. H. PUTNEY has been identified with refinery design, process and development for more than 30 years. A vice president of Stratford Engineering Corporation, he started his career with Sinclair Refining Company doing refinery construction work; later joined Cross Engineering Company, and moved over to The M. W. Kellogg Company when it replaced the Cross organization in 1927. He was with Kellogg until 1931 when he became chief mechanical engineer for Alco Products division of American Locomotive Company. He joined the Stratford firm in 1936 as chief engineer, and became associated with alkylation development and correlation. He was named vice president in 1950.

PROCESS ISSUE '55
18th Annual

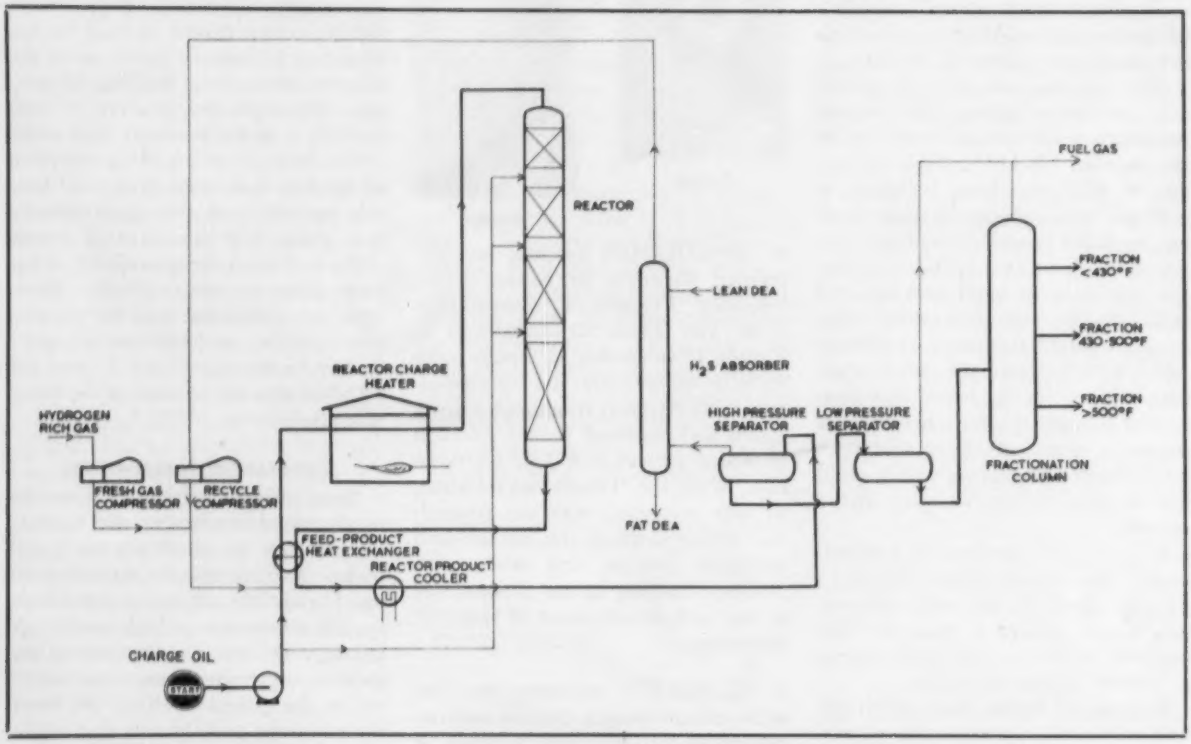

FIGURE 1—Flow diagram for Hydrodesulfurizer: Excellent liquid distribution achieved in the reactor beds.

SHELL "Trickle" Hydrodesulfurizer

H. G. Klinkert and H. M. Penning,
N. V. De Bataafsche Petroleum Maatschappij
The Hague, The Netherlands

First unit for this process is at Stanlow, England; operating data shows more than 90 percent of sulfur hydrogenated in light catalytically cracked cycle oils.

THE FIRST commercial application of the Shell trickle hydrodesulfurization process is the 7000 barrel per stream day hydrodesulfurizer erected at the Stanlow Refinery (England) of Shell Refining and Marketing Company Ltd.

In an earlier publication[1] the Shell trickle hydrodesulfurization process was described in detail. The main feature of the process is the application of low hydrogen recycle flow rates. As a result, only part of the charge oil will be vaporized. This operating technique involves a significant saving in operating and capital costs since the recycle hydrogen compressors are of reduced capacity and consume less power than in other, true vapour phase hydrodesulfurization processes; also less surface is required for heat transfer.

The process is suitable for desulfurization of any distillate, including vacuum distillates, as no vaporization of the charge oil is necessary. Although the various distillates need different processing conditions, these conditions do not vary so much that they cannot be applied in one and the same unit.

The design of the Stanlow unit has been directed primarily towards hydrodesulfurization of light catalytically cracked cycle oil although it will be understood from the foregoing remarks that quite a variety of other feedstocks can be processed as well.

The purpose here is to give a survey of the major operating results obtained in this unit since it was brought on stream in April, 1955.

Description of Unit—A simplified flow scheme of the unit as erected at the Stanlow refinery is shown in Figure 1 and is described as follows:

A hydrogen-rich gas obtained from an adjacent catalytic reforming unit is mixed with the hydrogen-rich recycle gas stream and the major part of the oil to be desulfurized.

The mixture is heated to reaction temperature first by heat exchange against reactor effluent and subsequently in the fired preheater. The heat developed during hydrogenation of the sulfur compounds is dissipated by injection of the remaining cold feed between the various catalyst beds.

Thorough mixing of hot and cold oil and liquid redistribution is obtained by installation of mixing-redistributing trays of special design. The reactor effluent is cooled first by heat exchange against reactor feed and subsequently in a product cooler.

In the high pressure separator a hydrogen-rich gas is flashed off and recycled after being scrubbed with diethanolamine solution to remove the hydrogen sulfide.

Means have been provided in the Stanlow design to raise, if required, the hydrogen concentration in the recycle gas without having to resort to bleeding off part of the gas. This leads to maximum use of available hydrogen which is particularly important in refineries processing Middle East crudes where the yield and purity of hydrogen from catalytic reforming is relatively low because of the paraffinicity of the naphtha, and on the other hand the hydrogen consumption in hydrodesulfurization is relatively high due to the high sulfur content of straight run and catalytically cracked distillates.

The high-pressure separator liquid is expanded into the low-pressure separator, and subsequently passed to a fractionating column provided with

TABLE 1
Hydrodesulfurization of Middle East Light Cat. Cracked Cycle Oil.

		PRODUCTS		
	Feed	Fraction Below 430 F.	Fraction 430-450 F.	Fraction Above 500 F.
Properties:				
ASTM distillation: (Fahrenheit)				
IBP	400	311	403	484
10 pct. vol. recovered at	480	318	419	509
50 pct. vol. recovered at	534	328	446	552
90 pct. vol. recovered at	612	344	467	617
FBP	648	378	511	653
Sulfur	2.48	<0.01	0.06	0.35
Diesel Index	21	....	....	31
Viscosity, Redwood I secs at 100 F.	....	....	30	35
Color Union	1½⁺	....	....	1½⁻
Octane numbers:				
CFR Research, without TEL addition	....	iC₅⁺ 0.16 ml TEL/gal.	....	....
Idem, with 1.5 ml TEL/gal.	....	iC₅⁺ 0.55 ml TEL/gal.	....	....
Aromatics, Pct. vol.	60	82	71	57
Yields, percent vol. on feed	100	5	25	72

TABLE 2
Hydrodesulfurization of a 70/30 weight mixture of light cat. cracked cycle oil and straight run heavy gas oil, both of Middle East origin.

		PRODUCTS		
	Feed	Fraction Below 430 F.	Fraction 430-450 F.	Fraction Above 500 F.
Properties:				
ASTM distillation: (Fahrenheit)				
IBP	426	291	392	500
10 pct. vol. recovered at	....	327	432	534
50 pct. vol. recovered at	....	340	446	581
90 pct. vol. recovered at	642	356	478	647
FBP	682	403	509	674
Sulfur, percent wt.	2.28	0.01	0.04	0.31
Diesel Index	32	....	....	43
Viscosity, Redwood I secs. at 100 F.	....	....	30	....
Color Union	....	....	....	1⁺
Octane numbers:				
CFR Research, without TEL addition	....	100	....	....
Idem, with 1.5 ml TEL/gal.	....	iC₅⁺0.3 ml TEL/gal.	....	....
Aromatics, percent vol.	....	72	66	....
Yields, percent vol. on feed	100	5	21.5	76

PROCESS ISSUE '55
18th Annual

two side-strippers. In this column the desulfurized product is stripped of hydrogen sulfide and light hydrocarbons—the latter introduced with the fresh, hydrogen-rich gas—and split into three fractions, boiling below 430 F, between 430 and 500 F. and above 500 F. respectively.

It should be noted that in cases where it is not desired to split the desulfurized product into three cuts, and where only a very small amount of lower boiling material is formed during the desulfurization, e.g. when processing straight run stocks, the unit can be considerably simplified, particularly in the low pressure section.

Operating conditions and results—The feedstocks processed so far are light catalytically cracked cycle oil and mixtures thereof with heavy straight-run gas oil both of Middle East origin. The major properties of these feedstocks are shown in Tables 1 and 2, together with the properties of the three product fractions.

With the cobalt-molybdenum-on-alumina catalyst used, the reaction temperatures required are low, ensuring a long catalyst life. In order to keep the reaction temperature within the desired range, when processing a stock containing in the order of 2.5 percent wt sulfur, cold charge oil is introduced directly into the reactor at a rate of about 20 percent on total charge.

Temperature control proved to be very easy in this way and no temperature run-aways have been observed. The use of a multi-bed reactor, with injection of cooling oil between the catalyst beds, not only provides operational flexibility, but also permits the adjustment of the temperatures in the individual beds during the course of a run in such a manner that optimum catalyst utilization, i.e. maximum catalyst life before regeneration, is obtained. The pressure drop over the reactor, height ca. 60 feet, is a few pounds per square inch only even at a throughput of 10,000 barrels per stream day.

The extent of sulfur removal obtained for both feedstocks proved to be above expectation: more than 90 percent of the sulfur had been hydrogenated. This favorable performance should be ascribed primarily to the excellent liquid distribution achieved in the reactor beds, which proved to be superior to that obtained in a pilot plant reactor.

After two months of operation there was no indication whatsoever that the catalyst activity was decreasing: the percentage desulfurization remained at the same level without the need of any adjustment of reactor temperature. The total liquid product yield is higher than 100 percent vol.

The major fractionator product stream, the fraction boiling above 500 F, obtained at a yield of 72-76 percent vol. on feed depending upon the feedstock, contained less than 0.40 percent wt. sulfur. The color and stability of this product are improved as compared with the desulfurizer charge.

The diesel index of this fraction was 31. When processing a mixture of 30 percent wt of Middle East straight run heavy gas oil and 70 percent wt of light catalytically cracked cycle oil, the diesel index of the 500 F. plus desulfurized fraction was 43.

The fraction boiling betwen 430 and 500 F. amounts to 20-25 percent vol. on feed. Its sulfur content is below 0.07 percent wt. Since this fraction is highly aromatic, it can be used advantageously as a tractor kerosine component.

Since the sulfur compounds present in light catalytically cracked cycle oil are predominantly of the alkyl-benzothiophene type, lower boiling aromatics will be obtained by conversion of such sulfur compounds. Since the sulfur content is highest in the lower boiling part of the cycle oil, a relatively high percentage of material boiling below 430 F. is obtained after fractionation, viz. 5-8 percent vol. on feed.

This premium gasoline fraction has the very attractive octane rating of over 105 when rated according to the CFR research method after addition of 1.5 ml TEL per U. S. gallon. Its quality decreases slightly when blends of cycle oil and straight run gas oil are processed, due to dilution with non-aromatic hydrogenated sulfur compounds. This fraction is essentially sulfur free in both cases.

From the foregoing it can be concluded that the results obtained so far in the first Shell "trickle" hydrodesulfurizer are extremely satisfactory.

This hydrodesulfurizer is the first of a series of hydrodesulfurization units to be built by Royal Dutch/Shell Group Companies, and by other oil companies under license from shell.

Meet the Authors

Klinkert

Penning

H. G. KLINKERT joined N. V. Bataafsche Petroleum Maatschappij (Royal Dutch Shell Group) in 1945 after serving two years as a plant technologist at the MEKOG fertilizer plant in IJmuden, Netherlands. Since, except for a year in Curacao, he has been assigned to the company's head office at The Hague where he has participated in the development of various petroleum refining and chemical processes. In the Netherlands West Indies, he served as acting chief technologist at Shell's Curacao refinery.

H. M. PENNING, with N. V. Bataafsche Petroleum Maatschappij since 1951, joined the company following a tour of duty with the Royal Dutch Naval reserve. Assigned first to the development of catalytic reforming and desulfurization at the Royal Dutch Shell Group's Amsterdam laboratories, he now works on the development and design of catalytic processes at the company's head office in The Hague. He, like his co-author, is a physics graduate from the Technical University at Delft.

ACKNOWLEDGMENT

The authors wish to thank the management of the N.V. De Bataafsche Petroleum Maatschappij for permission to publish the above account.

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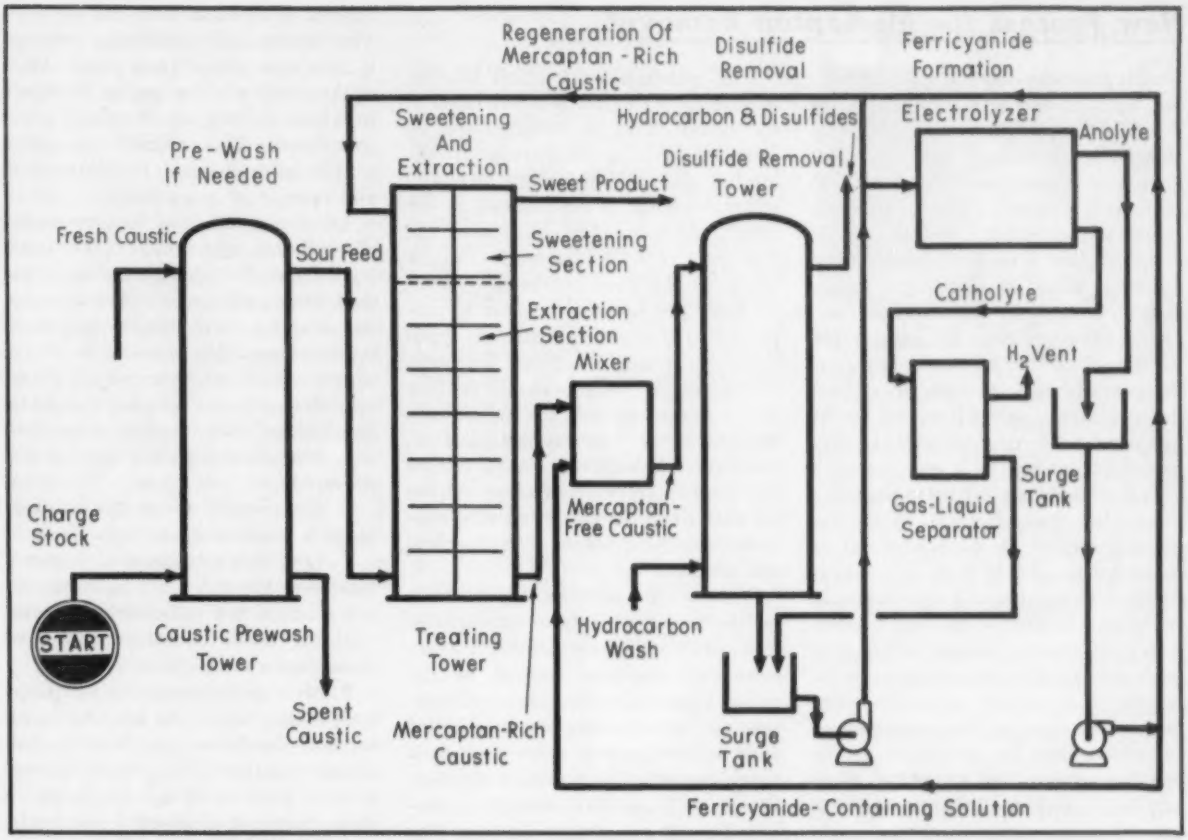

FIGURE 1—ADC electrolytic mercaptan extraction and sweetening process: Regeneration of caustic is complete.

New Process for Mercaptan Removal

Using sodium ferrocyanide as an additive to caustic soda, process uses electrolysis for regenerating the caustic.

Ralph Miller and Joseph H. Salmon
American Development Corporation, New York

THE AMERICAN Development Corporation offers a unique process for mercaptan removal or sweetening (or combined mercaptan removal and sweetening). It uses sodium ferrocyanide as an additive in small concentrations to caustic soda. The process is completely regenerative and accordingly consumes no chemicals. The operating cost is nominal, consisting almost entirely of the electric power cost in the electrolytic conversion of sodium ferrocyanide to sodium ferricyanide, the oxidation agent in the process.

The process includes the following features:

1. The regeneration step results in mercaptan-free caustic and consequent improved extraction over conventional processes.
2. A common reagent is used for both the regeneration and sweeting operations with attendant simplification of design and operation.
3. Ambient temperature processing eliminates the need for heat transfer equipment, steam or cooling water.

The process is especially suitable for treating straight run naphthas, LPG, natural and recycle gasolines and poly feed stocks. None of these stocks normally contain acid oils or H_2S which, if present, must be removed by an effective caustic prewash.

The flow diagram (Figure 1) illustrates one way in which the process may be carried out.

If the charge stock contains H_2S or acid oils it is scrubbed with caustic to the point where these impurities are eliminated. The charge stock is then introduced into one end of a liquid-liquid extraction system, pre-

ferably one that employs internal mixing such as the RDC contractor or the York-Scheibel type. The sour charge flows through the extraction section of the equipment counter current to a ferrocyanide-containing caustic soda solution. The ferrocyanide concentration is so low that it has no material effect on the ability of the caustic to extract mercaptans from hydrocarbons. Since the caustic fed to the extractor is mercaptan free, theoretically it is possible to extract the mercaptans to the point where the hydrocarbon is doctor sweet. Frequently, however, it is not economically feasible to achieve more than four theoretical transfer stages in the extraction section of the equipment or to use a ratio of volume of aqueous extractant to volume of hydrocarbon in excess of 0.3. The use of more transfer stages or greater solvent ratios provides only a minor improvement in the degree of extraction attained; hence the cost of securing this increment in extraction may be greater than the benefits secured. If a doctor sweet product is required, then a sweetening step is necessary.

As shown in the flow sheet, the hydrocarbon is usually still somewhat sour after passing through the mercaptan removal part of the equipment. By adding an additional transfer stage or two to the extractor, and spiking the alkali solution with dissolved ferricyanide, the alkali feed end of the system performs the sweetening step. That is, at the alkali solution feed end of the system, the mercaptans still present in the hydrocarbon are converted to disulfides by the ferricyanide contained in the caustic soda solution. The ferricyanide is reduced to ferrocyanide.

The ferricyanide content of the alkali solution fed to the treating vessel is adjusted to the minimum concentration which produces a doctor sweet product. In this way no ferricyanide is present when the aqueous alkali reaches the extraction section of the vessel. The aqueous alkali continues through the extraction section counter-current to the hydrocarbon and is continuously enriched in dissolved mercaptans as it moves towards the hydrocarbon inlet. The alkali solution leaves the system in substantial equilibrium with the incoming hydrocarbon.

The mercaptan-rich alkali solution leaving the extractor is regenerated in the mixer. This is accomplished by intimately mixing the mercaptan-containing alkali solution with an alkali solution similar in composition to the mercaptan-containing solution except that part of its ferrocyanide content has previously been converted to ferricyanide. The two solutions are so proportioned that an equivalent of ferricyanide is fed to the mixer for every equivalent of mercaptan sulfur that enters the mixer with the mercaptan-rich alkali. In this way complete regeneration is achieved irrespective of the mercaptan concentration of the solution from the treater or the ferricyanide concentration of the regenerant solution.

Although the aqueous solution leaving the mixer is free from mercaptans, it is mixed with the disulfides. To prevent the disulfides formed in the mixer from reentering the hydrocarbon, the aqueous solution is scrubbed with a hydrocarbon wash such as a heavy naphtha. To minimize disulfide return to the hydrocarbon, it is preferred to use a two stage scrubber. The sulfur concentration in the hydrocarbon wash can rise to 3 to 4 percent before it is necessary to replenish the first stage naphtha. Under these conditions the disulfides are effectively removed from the alkali.

As shown in the flow sheet the regenerated, disulfide-free alkali is divided into two streams. One stream is recycled to the mercaptan extraction step. The other flows to the ferricyanide formation part of the process. This stream flows into an electrolyzer of special design. Two streams emerge from the electrolyzer —an anolyte mixture and a catholyte mixture. The catholyte consists of a solution substantially equal in composition to the feed plus the hydrogen gas formed at the cathodes. This mixture flows to a gas-liquid separator in which the hydrogen is separated from the solution. The hydrogen is vented and the solution returned to the electrolyzer by way of the regenerated alkali surge tank.

The anolyte leaving the electrolyzer consists of a ferricyanide-containing alkali solution plus some oxygen gas, the origin of which is explained below. The anolyte flows to a small surge tank. This provides a means for the oxygen to separate from the solution. The ferricyanide-containing solution is then recirculated by a pump. Most of the solution is pumped to the mixer in which the regeneration step is accomplished. The remainder is added to the solution used for sweetening and mercaptan extraction.

All of the plant can be constructed of ordinary steel except the small ferricyanide containing surge tank, the ferricyanide solution circulation pump, the small length of line carrying ferricyanide-containing caustic and the upper section of the extractor. Ferricyanide containing solution should be handled in 18-8 stainless since ordinary iron reduces ferricyanide to ferrocyanide.

It was possible to devise this process as a result of three discoveries:

1. Low concentrations of ferricyanide ion ($Fe(CN)_6^{-3}$) in strong alkali solution is a sufficiently powerful oxidizing agent to convert dissolved mercaptides to disulfides.

2. Mercaptan-containing hydrocarbons boiling below the kerosine range are completely sweetened when intimately contacted with an aqueous caustic soda solution containing a slight excess of dissolved ferricyanide.

3. By subjecting an alkali solution containing a small concentration of dissolved ferrocyanide to anodic oxidation in a specially designed electrolytic cell, a useful fraction of the ferrocyanide can be oxidized to ferricyanide with excellent current efficiencies.

Process Chemistry—The chemical reaction representing the conversion of sodium mercaptide to a disulfide may be written:

$$2\,RS\,Na + 2\,Na_3\,Fe(CN)_6 = RSSR + 2\,Na_4\,Fe(CN)_6 \quad (1)$$

The electrolytic conversion of sodium ferrocyanide to sodium ferricyanide is:

$$2Na_4\,Fe(CN)_6 + 2H_2O + 2\ Faradays = 2Na_3\,Fe(CN)_6 + H_2 + 2\,NaOH \quad (2)$$

It will be noted that one equivalent of ferricyanide is reduced to ferrocyanide for every equivalent of mercaptan sulfur converted to disulfide sulfur.

These two reactions show that mercaptans are oxidized to disulfides at the power expenditure necessary to convert ferrocyanide to ferricyanide. This conversion is carried out in an electrolyzer devised for this purpose.

Electrolyzer Design and Operation—The electrolyzer used for ferricyanide production is a multiplicity of

specially designed electrolytic cells assembled on a filter press skeleton. Filter press technique is employed to feed the individual cells from a common header and to remove the electrolysis products by the same device. Each individual cell is made up of three compartments, a center feed compartment, and compartments to receive the analyte and catholyte. By using electrodes through which the solution passes from the center compartment to the receiving compartments, the design and construction of the cells becomes extremely simple. Each cell is made up of a perforated stainless steel sheet cathode and a perforated stainless steel sheet anode. The anode sheet is covered with a multibraided stainless steel wire cloth. This device permits exceedingly intimate contact between the electrolyte and the anode. This is one of the requirements for securing the high current efficiency obtained.

In carrying out the electrolysis the electrolyte is circulated at a flow rate of about one gallon per minute per square foot of superficial electrode area. Current densities of about 100 amperes per square foot are used. At these flow rates and current densities, from 10 to 30 percent of the ferrocyanide in the solution is converted to ferricyanide. This small degree of conversion is not detrimental to the overall process and makes high current efficiencies possible. The voltage drop per cell is slightly more than 3 volts at this current density. Under these conditions current efficiencies in excess of 50 percent are secured. Electrolyzers made up of 60 cells with a total anode area of 240 square feet have been designed. An electrolyzer with this anode area has the capacity to handle about 750 pounds of mercaptan sulfur per day.

Equation (2) in the foregoing is the useful reaction taking place in the electrolyzer. Caustic soda is formed at the cathode along with the hydrogen. Ferricyanide is formed at the anode. That portion of the current which does not convert ferrocyanide to ferricyanide is wasted in the electrolysis of water. This is the source of the oxygen mentioned above. By diminishing the current density and increasing the circulation rate through the electrolyzer, the needed voltage decreases and the current efficiency goes up.

A 60-cell 4-square-foot electrolyzer capable of converting 750 pounds of mercaptan sulfur a day will require 400 amperes of direct current. About 200 volts will be needed to pass this current through the 60 cells. Taking the efficiency of the rectifier into consideration, the A.C. power taken by the electrolytic equipment will be about 90 kw. Hence, about three kilowatt hours are needed for the conversion of each pound of mercaptan sulfur to disulfide sulfur. Roughly speaking this represents an energy expenditure of about 75 kw hours of A.C. power for every 1000 barrels of charge per .01 percent of mercaptan sulfur in the feed.

As a rough gauge of the capital cost of the special equipment—namely the electrolyzer and rectifier—required for the process, it is estimated that this will amount to approximately $350 per pound of mercaptan sulfur handled per day. Hence, for 500 pounds daily of mercaptan sulfur the special equipment would cost about $17,500.

The solution used in the process usually contains 12 percent of NaOH plus 35 grams per liter of sodium ferrocyanide decahydrate. Sodium ferrocyanide decahydrate is a readily available innocuous chemical which sells for about 15 cents per pound. This makes for a treating solution which is low in first cost. Loss of ferrocyanide is only sustained as the result of mechanical leaks since there is no inherent consumption of reagents in the mercaptan oxidation step of the process.

Testing Procedure—Ordinarily, a test program is required to determine the effectiveness of a mercaptan removal process when the process is to be applied to a specific feed stock. To do this the regeneration step of the process normally should be carried out as well as the extraction step. Only in this way is it possible to determine the effect of the residual mercaptan content of the regenerated caustic in other processes.

In the present process, however, as the regenerated caustic is mercaptan-free, the degree of mercaptan removal is dependent solely on the ability of fresh caustic soda to extract mercaptans. Consequently, all that is required is a series of extractions with about 12 percent of fresh NaOH on a sample of the charge to ascertain what degree of mercaptan removal will be achieved. The capacity of the regeneration system is determined solely by the number of pounds of mercaptan to be handled per day.

The advantages of the process include:

1. Improved extraction due to the use of mercaptan-free reagents.
2. Low capital and operating costs.
3. The flexibility of extracting mercaptans within economic limits followed by sweetening, if desired, at nominal additional cost.
4. A multiplicity of streams may be treated with a common treating solution and a single regeneration system.
5. Ambient temperature operation.
6. In some instances, a doctor sweet product is obtained solely by extraction which is rarely possible with other regenerative processes.

Meet the Authors

Salmon

Miller

JOSEPH H. SALMON, president of American Development Corporation, has been active in the petroleum industry for more than 32 years, of which 27 were with Shell Oil Company. A graduate of Pennsylvania State University and holder of a professional industrial engineer's degree from there, he also received a law degree from St. Louis University. In addition to his other activities, Salmon serves as a management consultant to the oil and gas industries.

RALPH MILLER is technical director for American Development Corporation. Prior to joining the company, he was research director with the Chemical Foundation. A chemical engineering graduate from Columbia University, he holds a number of patents in the petroleum and chemical fields.

PROCESS ISSUE '55
18th Annual

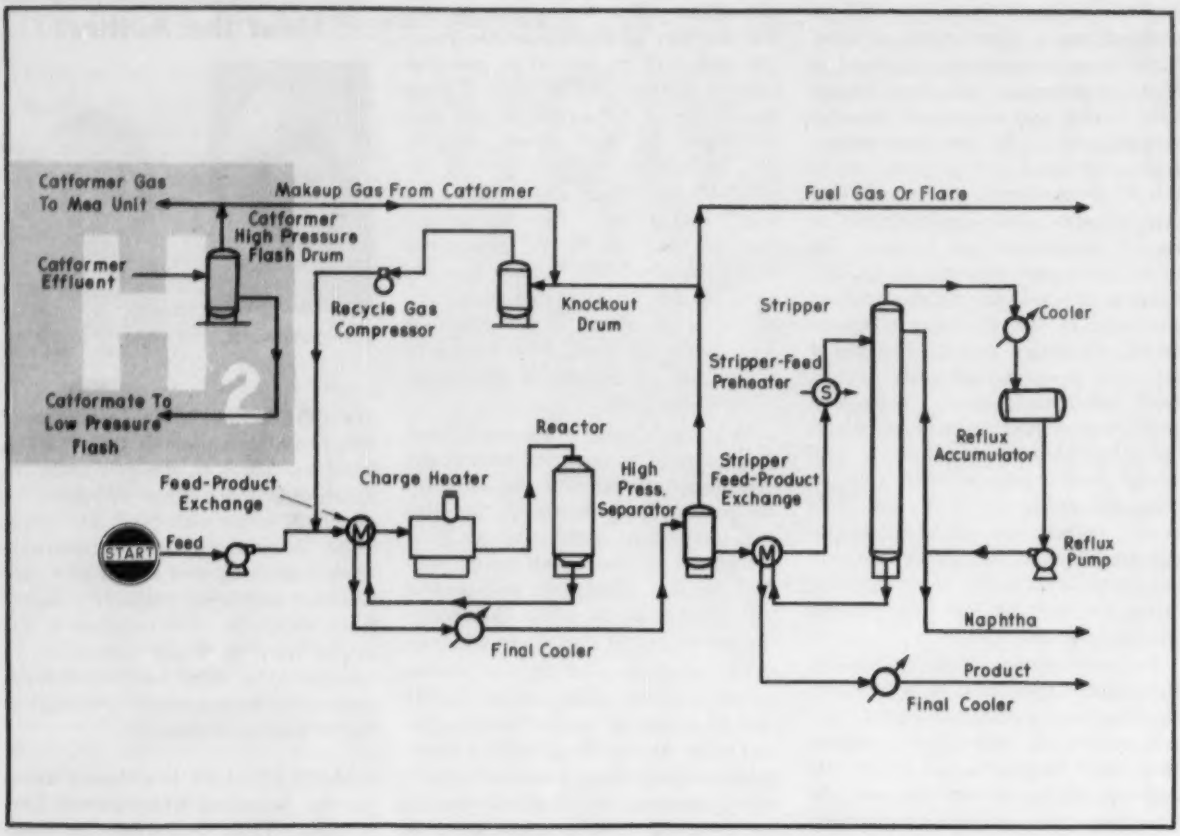

FIGURE 1—Flow diagram for Diesulformer: It can be operated without external hydrogen.

Diesulforming Operates This Way

Operating data is from the first diesel desulfurization unit on stream in the U. S.

F. B. Odasz and J. V. Sheffield,
Husky Oil Company,
Cody, Wyoming

IN THIS PROCESS, hydrocarbons with a high sulfur content react with hydrogen containing gas in a fixed bed catalytic reactor to produce over 100 volume percent of low sulfur hydrocarbon and hydrogen sulfide. Although any sulfur-bearing stock may be charged to the unit, distillates in the diesel fuel boiling range are the most popular charge.

Similarly, hydrogen from any source may be used, but waste gases from catalytic reformers are most popular. A small amount of gasoline is produced in the process.

How the process developed—The Husky Oil Company is primarily dependent upon Oregon Basin crude which contains 4.5 percent sulfur and 45 percent asphalt. This combination provides base stocks for manufacturing a wide variety of excellent asphaltic products, but for years had necessitated extensive refining and blending to manufacture acceptable distillate products.

Faced with the prospect of a diminishing market for its distillates, the company decided to attempt to develop an economically feasible process of its own. The first experimental runs were made in December, 1950, at Montana State College under the direction of Dr. Lloyd Berg, chairman of the Chemical Engineering department. These runs were based upon improvements in the early German hydrogenation research efforts performed with molybdenum and other

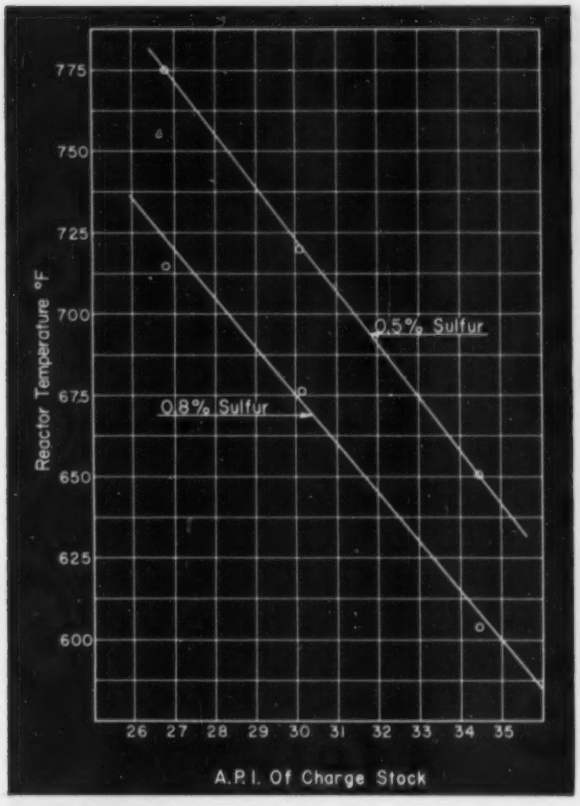

FIGURE 2—Required reactor temperature and gravity of charge stock (for product of constant sulfur %) correlate well.

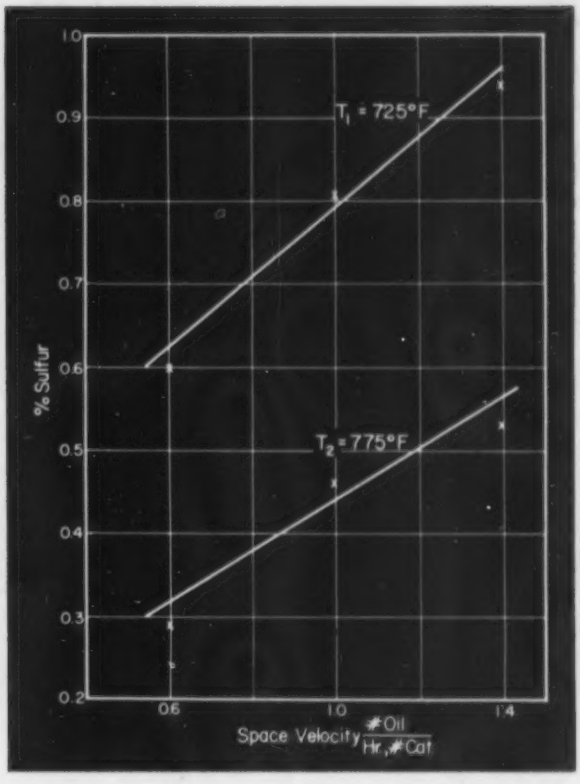

FIGURE 3—Relationship between the sulfur in the product obtained by operating at a given temperature and space velocity is fundamental.

oxides during the late 1920's and early 1930's.

After two years of development work, in which other processes were simultaneously evaluated, success was attained in the college's 0.01 barrel per day laboratory unit. A two barrel per day pilot plant was constructed at Husky's Cody laboratories in November, 1952, to obtain engineering data for the design and construction of a 1000 barrel per day commercial unit.

By telescoping pilot plant work and promptly translating results into engineering specifications, the commercial unit was put into operation in August of 1953, earning for it the honor of being the first diesel desulfurization unit on stream in the U. S.

Another Husky first is under way in Canada—the first Canadian diesulformer is being constructed for Husky Oil & Refining, Ltd., at the recently acquired Moose Jaw refinery. Like the Cody unit, the hydrogen will be supplied by the waste gases of a 1000 barrel per day Atlantic catformer. There will be no major design changes from the highly successful unit operating at the Cody refinery.

Description of process—As shown in the flow chart (Figure 1) the diesulformer is simple in design and closely integrated with the catformer operation. One man is able to operate both units and still have time to weigh about 20 tank trucks per shift.

Distillate feed stock and hydrogen are first preheated by exchange with reactor effluent. The combined feed is then heated further in a small furnace to not over 800 F. The charge then passes down through a fixed-bed catalyst chamber. After heat exchange with the charge stock, the product is

TABLE 1

Inspections on Charges and Products

	LIGHT DIESEL		HEAVY DIESEL		No. 2 BURNER FUEL		No. 1 BURNER FUEL	
	Charge	Product	Charge	Product	Charge	Product	Charge	Product
°API	35.9	37.9	32.3	35.0	30.2	33.2	39.2	40.6
Percent sulfur	1.32	0.21	1.77	0.37	2.2	0.35	1.02	0.105
Initial	361	371	392	362	473	415	379	363
10 percent	422	424	464	451	516	512	408	393
50 percent	491	493	554	552	570	564	440	432
90 percent	601	597	619	611	624	617	495	488
End point	666	663	674	664	656	658	533	545
Flash	155	160	165	160	230	202	154	147
Anilie point, F	142	148	145	163	142	152	136	143
Pour point	—20	—20	0	0	5	5	—50	—50
Product yield, vol. percent	....	97.3	....	98.6	....	98.4	....	96.2
Naphtha yield, vol. percent	....	2.7	....	1.5	....	1.7	....	4.0
Percent S removal	....	84	....	79	....	84	....	90
H_2 consumption, s.c.f. per bbl.	....	115	....	138	....	150	....	93
Odor	Poor	Good	Poor	Good	Poor	Good	Poor	Good
Doctor	....	....	....	....	....	....	DNP	Pass
Centane	47	50	48	51	48	52	45	47

PROCESS ISSUE '55
18th Annual

Diesulforming Operates This Way . . .

Other charge stocks have been piloted . . .

Canadian Distillate—In order to design the Canadian diesulformer, inspections were made of the charge stock. The remarkable similarity to the Oregon Basin distillate led to a run under the same condition as a control Oregon Basin run in the commercial unit in which the charge stock was of the same gravity as the Canadian charge stock. The product from the commercial unit, however, was stripped, whereas the pilot plant samples were not.

The test results on both charges and products are shown below:

Test	Canadian		Oregon Basin	
	Charge	Product	Charge	Product
API	40.1	43.0	39.2	40.9
Distillation:				
IBP	320	134	368	352
5	342	305	392	362
10	362	327	396	382
20	374	351	405	392
30	390	368	412	400
40	406	381	420	409
50	424	398	428	....
60	456	420	438	429
70	472	442	450	441
80	502	469	463	455
90	546	510	482	475
95	598	543	498	484
E.P.	646	595	519	529
Recovered	98.0	98.5	98.5	98.5
Residue	1.4	1.0	1.0	1.0
Loss	0.6	0.5	0.5	0.5
Pour	Below —25	....	Below —25	Below —25
Aniline point	136.5	....	136	142.5
S%	0.81	0.025	0.98	0.166
Flash PMCC	122	....	154	135
Corrosion	Neg.	Neg.	....	....
Nitrogen	.025	.017	....	....

As a result of these runs, Husky's management felt confident that successful operation could be obtained in the Canadian commercial unit with no radical changes in design. This unit will be on stream in September, 1955.

separated from the hydrogen rich gas in a flash drum. A gas-engine driven compressor recycles the gas back to the incoming feed.

The liquid effluent from the flash drum is stripped of hydrogen sulfide and any low-flash constituents. This sweet, desulfurized diesel fuel is then stored for marketing. No further treatment is necessary.

The small amount of H_2S saturated naphtha recovered from the stripper overhead is rerun through the refinery crude fractionator.

The primary purpose of the diesulformer is to reduce the sulfur content of the charge stock. However, the process also removes nitrogen and oxygen, and provides the additional advantages of color, odor, and cetane improvement.

Most of the research on the process has been on Oregon basin stocks, but other types of feed stocks are now being investigated to determine the commercial versatility of the process. The optimum economic conditions of operation depend mainly upon the characteristics of the charge stock.

For example, in upgrading Oregon Basin charge stocks, the diesulformer operates at 450-550 pounds per square inch gauge and not over 800 F. inlet temperature to the reactor. The hydrogenation reaction is exothermic, resulting in a temperature rise through the bed of 20-40 F., depending upon the amount of sulfur in the particular charge stock. In contrast to the catformer recycle gas which must be scrubbed of H_2S, the excess reformer gas containing 90-95 percent hydrogen may be charged directly to the diesulformer and recycled.

Catalyst activity has been remarkably good. The original catalyst pellets are still as active as when the reactor was first charged. Provisions to regenerate the catalyst in place with the mixture of steam and air have been included in the design. In April, 1955, when the normal pressure drop of 10-15 psig through the reactor began to build up to 75-100 psig, the catalyst unit was regenerated and the vessel inspected. A layer of dirt and iron oxide was found on the surface of the alumina balls at the top of the catalyst bed. Consequently the catalyst was dumped, screened, and recharged. Since then, the pressure drop has re-

About the Authors

FRANK B. ODASZ, as assistant director of technical service with Husky Oil Company, is concerned with both light and heavy petroleum products and refinery problems. Formerly with Parmelee Motor Fuel Company, he was assigned to asphalt-products development shortly after joining the Husky company. He was promoted to his present position in 1953. Odasz, received both his bachelor's and master's degree from the Polytechnic Institute of Brooklyn. He is author of an article on statistical methods appearing in the PETROLEUM REFINER for June 1955.

Odasz

J. V. SHEFFIELD is an engineer with Husky Oil Company's Technical Service department at Cody, Wyo. A 1949 graduate from Montana State College with a degree in chemical engineering, Sheffield previously was associated with The Carter Oil Company, Refinery Engineering Company and Lake Superior Refining Company.

Sheffield

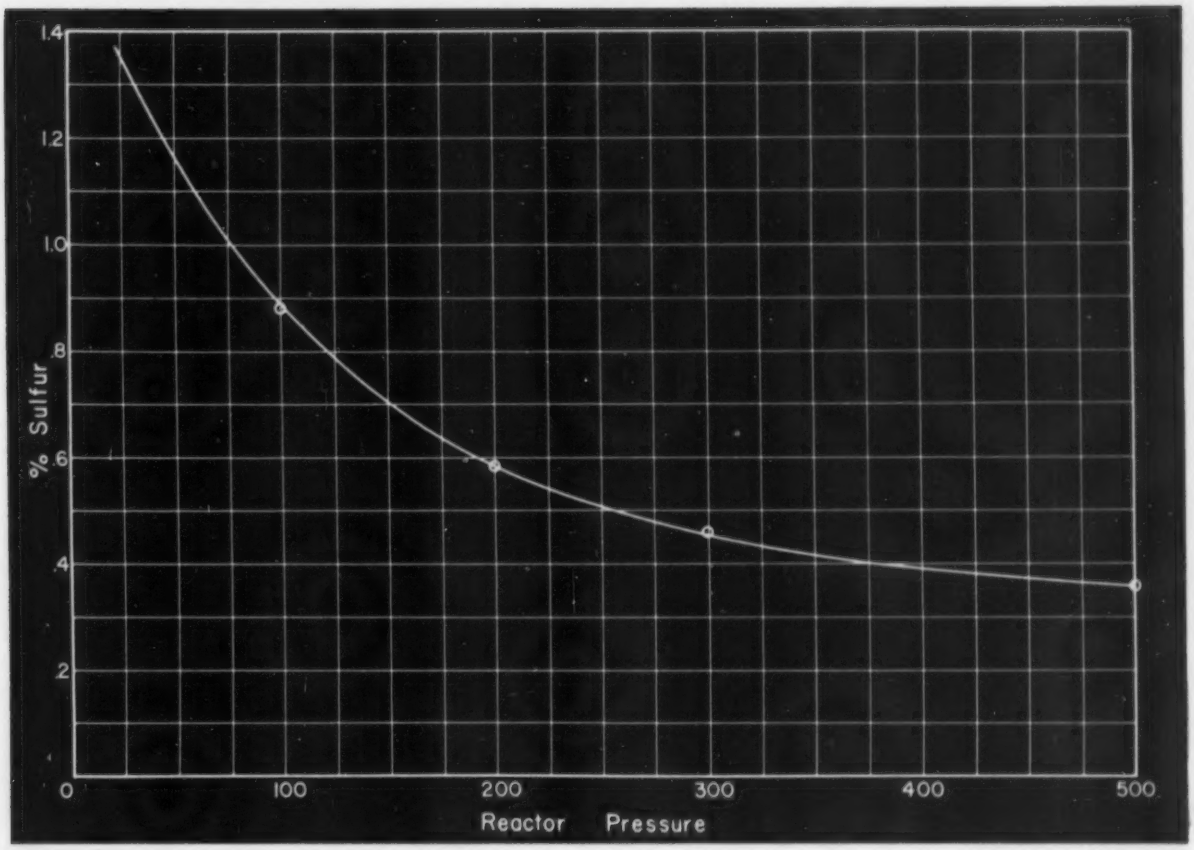

FIGURE 4—Total pressure in the reactor and the partial pressure of the hydrogen in the reactor both affect the degree of desulfurization.

turned to normal and catalyst activity is still excellent.

Because the catalyst is extremely stable at these temperatures, repeated regenerations are possible. Therefore, the catalyst is expected to last indefinitely under normal operating conditions. Most of the Cody operation has been on the 34° API stock, reducing its sulfur content from 1.8 to 0.3 percent. Table 1 lists typical inspections of the charge stocks and products for the Cody unit.

Independent variables—The main independent variables in the process are:

- Charge Stock
- Temperature
- Space Velocity
- Pressure
- Hydrogen Purity
- Recycle Rate

Charge stock—No generalized relationship has been developed to indicate the optimum conditions for new charge stocks. However, on Oregon Basin distillates the curves of Figure 2 show that under the same operating conditions the degree of desulfurization is roughly proportional to the API gravity of the charge stock.

Nevertheless, for charge stocks from other crude oils, it is strongly recommended that a test run be made at the Cody pilot plant in order to select proper operating conditions.

Temperature—Like many other reactions of this type, the efficiency is directly proportional to the reactor temperature; however, excessively high temperatures cause cracking of the hydrocarbons to coke which gradually deactivates the catalyst. It is a unique feature of diesulforming that conditions are selected which allow long runs between regenerations. For instance, the first run at Cody lasted 20 months. This permits longer on-stream times, lower maintenance cost, and longer catalyst life—all of which contribute to optimum economic operation.

Space velocity—Space velocity is the next most important variable in diesulforming. It is measured as the pounds of oil charged to the reactor per pound of catalyst per hour of operation. Diesulforming has been successful at space velocities from 0.5 to 5.

Optimum selection of this variable is very important in the design of the reactor. At both Cody and Moose Jaw, it has been decided to overdesign the reactor to some extent in order to allow for the potential growth of the refinery. For instance, the Cody unit was originally designed for 650 barrels

PROCESS ISSUE '55
18th Annual

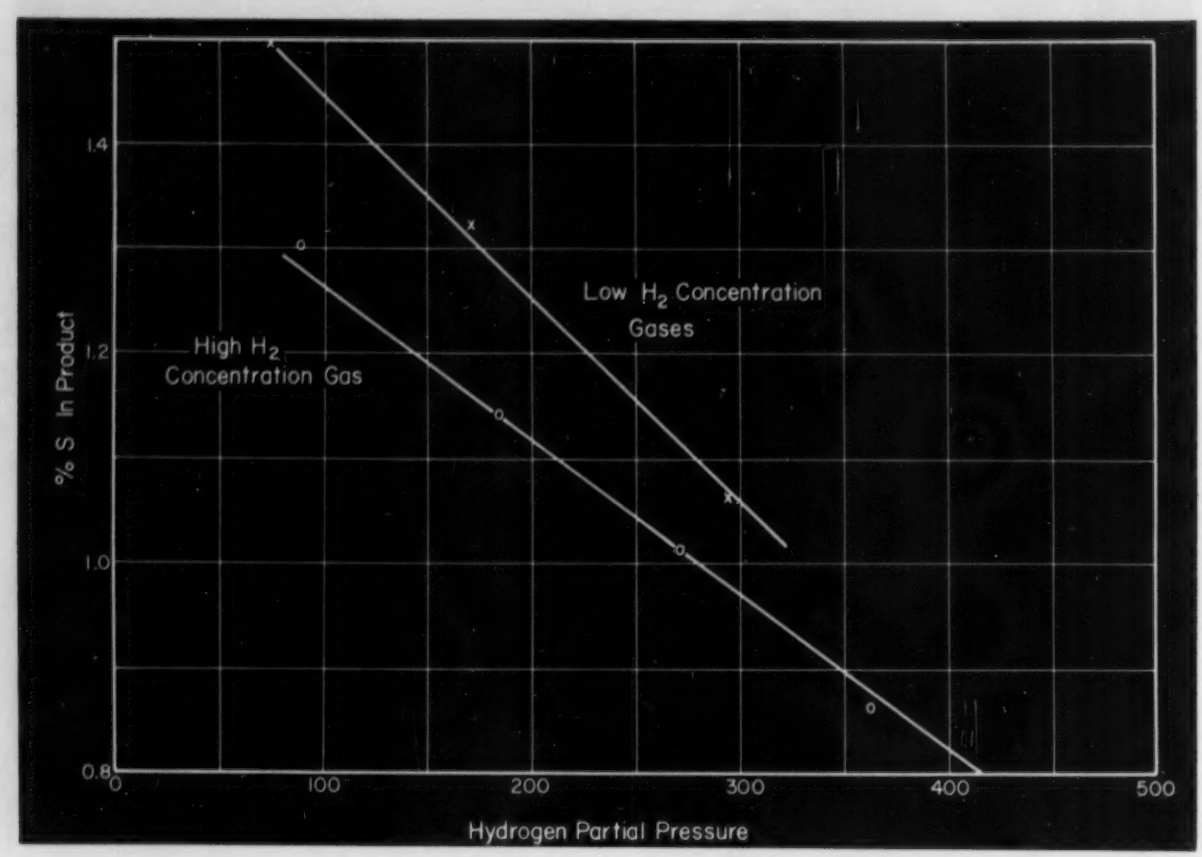

FIGURE 5—Even low H_2 concentration streams can be effectively desulfurized by the process.

per day, but this year it has been performing at the rate of 1000 barrels per day by making only minor changes in the heat exchangers.

There is a fundamental relationship between the sulfur in the product obtained by operating at a given temperature and space velocity. For 500 psig using 95 percent H_2 from the catalytic reformer, this relationship may be expressed as follows for the pilot plant. Commercial operation has been consistently better than this.

$\%S = 6.99 - 0.009T6 + 0.75V$
T = Reactor temperature, F.
V = Space velocity, # oil, per # catalyst per hour
%S = Percent sulfur left in the product

Figure 3 shows typical operating data which illustrates this relationship.

Pressure—Two pressures must be considered: one is the total pressure in the reactor; the other is the partial pressure of the hydrogen in the reactor. Figure 4 shows the effect of reactor pressure on the degree of desulfurization obtained in the small pilot plant. The degree of desulfurization is directly proportional to both the total pressure and to the hydrogen partial pressure. At any given total pressure, the higher the hydrogen concentration the more efficient will be the degree of desulfurization.

Hydrogen concentration—A further illustration of the effect of hydrogen concentration on efficiency of desulfurization is shown in Figure 5. In this case the effect of a very wide range of H_2 concentrations were tested on 30 API Oregon Basin distillate containing 2.1 percent sulfur. The percent sulfur in the product is inversely proportional to the purity of the hydrogen containing gas.

It is important to note, however, that even low H_2 concentration streams can be effectively desulfurized by the diesulforming process. This means that a catalytic reformer is not vital to diesulforming. For instance, cracker gas, hydroformer gas, and coker gases containing hydrogen may all be used.

Recycle rate—There are two main reasons for recycling the hydrogen-rich gas. One is to decrease the resistance of the absorbed film on the surface of the catalyst, thereby increasing the rate of diffusion of reactants and products from the surface of the catalyst. This allows lower pressures and permits higher space velocities than if no recycling were used.

The second reason is to provide a means of utilizing all the available hydrogen. For instance, the velocity of the hydrogen gas through the reactor in a once-through operation may exceed the capacity of the hydrogen source with the result that the pressure would drop below operable limits. With recycle, proper partial pressures

are obtained to obviate the need for higher operating pressures and such other conditions affecting the diffusion rates.

Regeneration—The diesulformer can be regenerated simply by burning the catalyst off with an air-in-steam mixture. To regenerate, the unit is shut down and purged of all hydrogen and hydrocarbons. After the necessary regeneration connections are made, steam is introduced through the reaction system. The temperature of the steam is raised to 500 F with the fired heater. Air is slowly introduced into the steam using care to keep the burning under control.

The burning is controlled so that the catalyst bed does not get over 1100 F. The amount of air used will depend on the steam available to cool the catalyst bed and control the burning. When the bed has burned thru at 500 F., as evidenced by a drop in temperature in the reactor outlet, the inlet temperature is increased to 700 F. to burn more contaminants from the catalyst. This procedure is followed again at 900 F. and finally at 1050 F. Flue gas analyses of the effluent mixture are the best indication of the degree of regeneration. After regeneration, the unit may be started up in the normal manner.

Equipment size—Considerable appreciation in the degree of desulfurization was observed as the process was developed from small to large equipment. Figure 6 shows that under the same conditions of operation the 0.01 barrel per day unit desulfurized to 0.5 percent S at 760 F., the 2 barrel per day unit at 735 F., and the 1000 barrel per day commercial unit at 720 F. This appreciation in activity is not fully understood but may be a function of the ratio of reactor diameter to catalyst diameter.

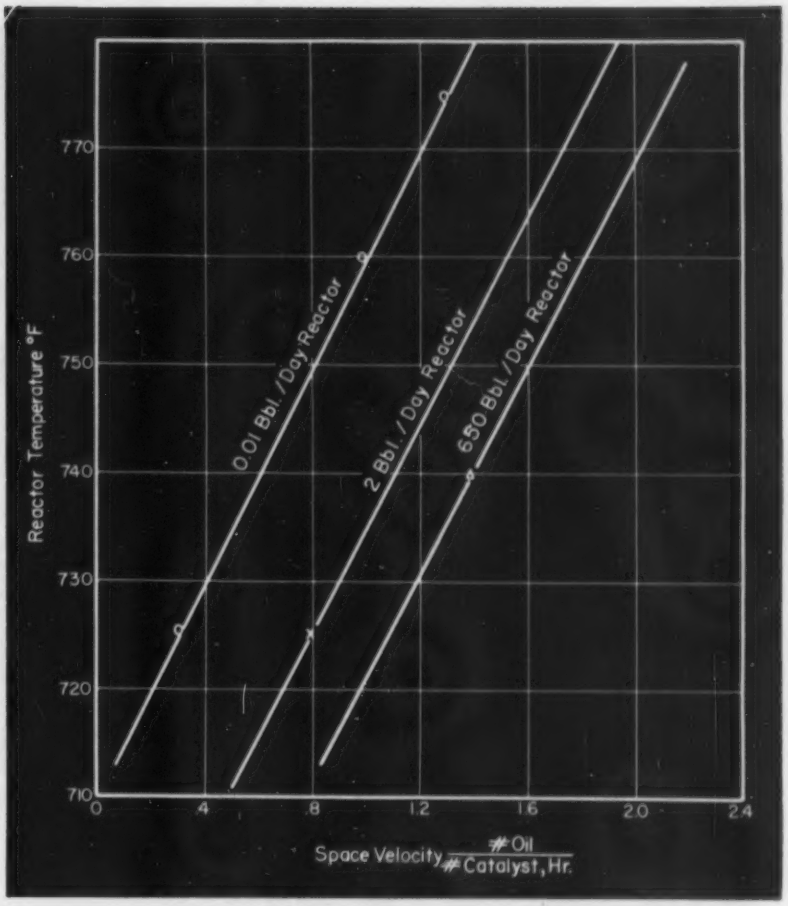

FIGURE 6—Considerable appreciation in the degree of desulfurization was observed as the process developed from small to large equipment.

Modifications in operation—Several modifications in the original flow chart are economically feasible in certain cases.

1. **No recycle, normal pressure.**

The capital investment in a recycle compressor and its concurrent operating costs can be avoided in the case where an abundant source of hydrogen is available for a relatively small diesulformer. Once thru operation at the normal pressure range of 450-550 psig is feasible where enough H_2 is present to maintain a hydrogen rate of about 2500-4000 cubic feet/barrel charge depending upon the API and % S of the charge.

2. **No recycle, high pressure.**

No recycle is necessary when nominal amounts of hydrogen are available if the pressure of the hydrogen is sufficiently increased. For example, equivalent results were obtained by operation at 775 psig with no recycle as are obtained at 500 psig with 8000 cubic feet/barrel recycle.

Dual reactors in parallel is another modification that is feasible in the case where the severity of operation results in severe deposition of coke on the catalyst so that frequent regeneration is required. With dual reactors, one can be on-stream while the other is being regenerated. The cost of the extra reactor and catalyst can be more than offset by the upgrading of the stock.

These examples show that economic advantages may be gained by modifying a particular design to take advantage of local conditions.

Economics—The diesulforming process may be licensed from Husky Oil Company of Cody, Wyoming, for $.01½ per barrel of fuel product, $.06 per barrel of specialty product, and $.05 per barrel of gasoline product; or a fully paid royalty at the rate of $.10½ per barrel of fuel product, $.42 per barrel of specialty product, or $.35 per barrel of gasoline product.

A prospective licensee may arrange to have his charge stocks evaluated in the Cody pilot plant prior to actual licensing.

ACKNOWLEDGMENT

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PROCESS ISSUE '55
18th Annual

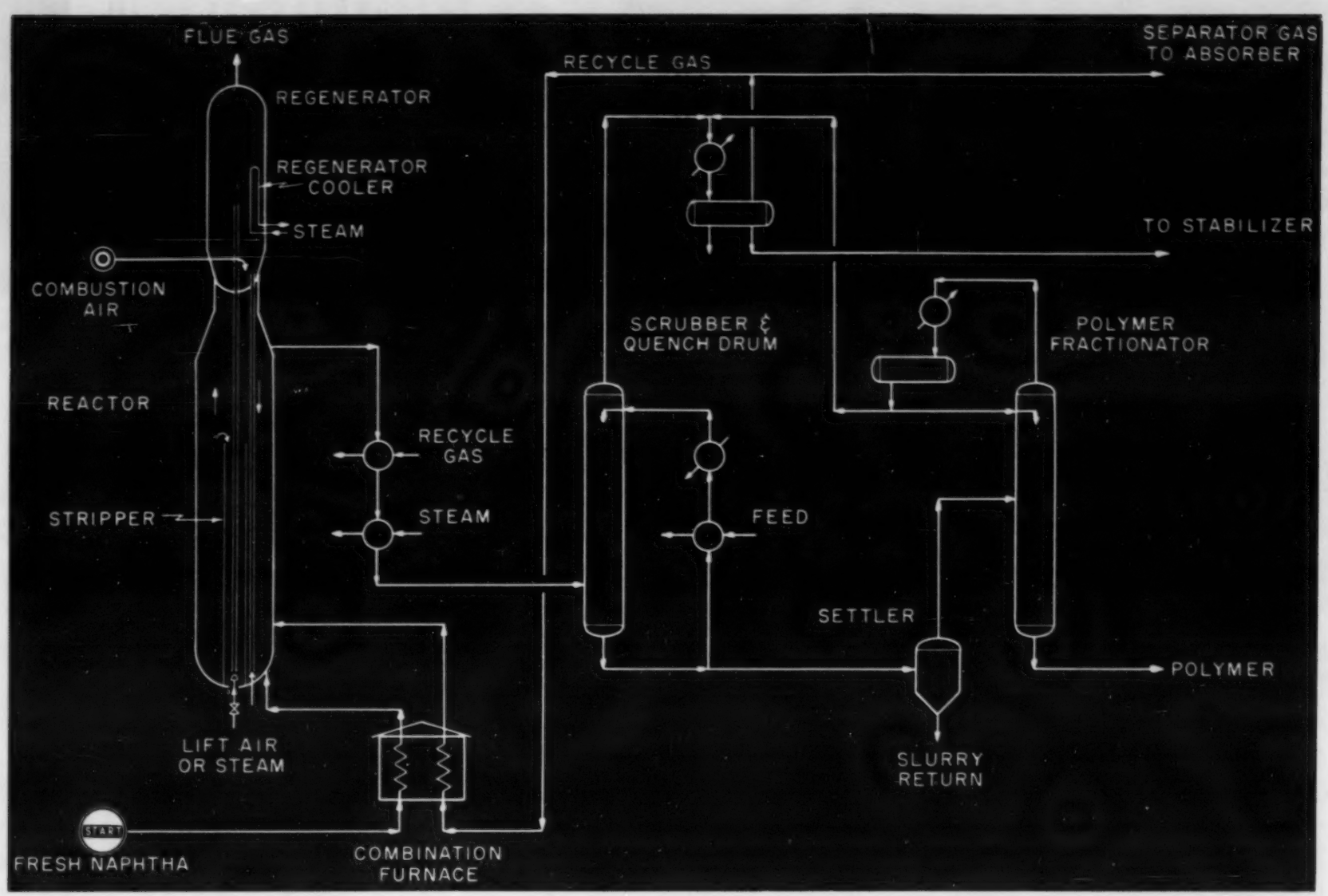


FIGURE 1—Flow diagram for first Orthoformer: Pretreatment of feed stock is not required.

Orthoforming Unit Produced 100 Clear

Robert G. Christopher
The M. W. Kellogg Company
New York

This was the unit which was destroyed in the refinery explosion at Whiting, August 27.

ORTHOFORMING is a continuous and regenerative fluid catalytic reforming process employing a molybdenum type catalyst and characterized by integration of the reactor, regenerator and stripper similar to the Orthoflow fluid catalytic cracking unit.

Mechanical Features—The integration of the high pressure internally insulated reactor and regenerator is achieved without external expansion joints by means of ingenious design and K-welding of the common head intersection with the two vessel shells, and permits all joints to be UW-51 quality butt welds. Accordingly the hazards of fatigue or shock failure in this area of combined pressure, intersection expansion and stiffness differentials and thermal gradient effects are minimized.

The vertical and straight catalyst transfer lines, provided by this vessel arrangement, afford more dependable smooth flow with reduced erosion, maintenance and operating upsets due to plugging, slugging, etc.; also heat loss from these lines is eliminated. The special type catalyst flow valves developed for Orthoflow fluid catalytic cracking service and applied to Orthoforming service enhance uniform control, minimize maintenance.

Catalyst—The catalyst is a precipitated alumina gel impregnated with a molybdenum salt solution with MoO_3 the active ingredient and is very rugged as demonstrated by its World War II use in fixed bed units for toluene production. Continuous regeneration disposes of deposited sulfur and coke; this retention of sulfur by the catalyst eliminates corrosion problems at subsequent locations in the flow system; also there are no detrimental effects on the catalyst by contaminants such as arsenic, other metals, etc.

Feedstocks—This process is extremely flexible and versatile with respect to varying operating conditions. As a result, Orthoforming can be readily adapted to processing a wide variety of feedstocks including any virgin or cracked fractions in the gasoline and kerosine boiling range. Pretreatment of the feedstock is not required for reasons already given.

However, feed preparation may be incorporated dependent on economic considerations. Fluid hydroforming pilot plant runs on a naphtha produced by delayed coking a California reduced crude, showed a reduction in the sulfur content from 0.91 to 0.015 Wt. percent while, at the same time, the octane number was increased. The first commercial Orthoformer built for The Standard Oil Company (Indiana) at Whiting, Ind., was designed to process a 0.2 Wt. percent sulfur content heavy naphtha containing 13 percent of coke still naphtha.

Operating Conditions—For the most part operating conditions are determined by the type and boiling range of the feedstock and the desired reformate octane level which may be as high as 98 or 100 F-1 clear. In general the reactor operating conditions are selected within the following limits:

Operating Pressure—PSIG	200-250
Reactor Temperature—°F	900-950
Recycle Gas Rate—SCF/B	4000-8000
Catalyst/Oil Ratio—Wt.	0.25/1.00
Space Velocity—Wt.	0.3-0.8

Process Flow—The Orthoformer feedstock and recycle gas are heated in separate coils of a combination furnace. Both streams then enter the reactor and pass upward through a fluidized catalyst bed where conversion of the feed takes place. Product vapors carrying some entrained catalyst pass through cyclones from which the separated catalyst is returned to the fluidized bed. Relatively catalyst-free hydrocarbon vapors are processed in a conventional recovery system.

The spent catalyst continuously flows into a central annular stripper and downward to the bottom of the riser where it is airlifted into the regenerator where coke and sulfur deposits are burned off with air. Regenerated catalyst is withdrawn downward through a standpipe, and returned into the reactor bed.

The flow of spent catalyst into the riser leading to the regenerator is controlled by a special design of a hollow stem plug valve whereas the return of regenerated catalyst to the reactor is regulated by a similar solid stem plug valve located at the bottom of the standpipe; the importance of these special valves was previously mentioned.

Commercial Operations—Representative current operating conditions and yields from the 30,000 bpsd Orthoforming unit built for The Standard Oil Company (Indiana) at Whiting, Ind., are as follows:

Operating Conditions	
Reactor Temperature—°F	890
Reactor Pressure—PSIG	210
Recycle Gas Rate—SCF/B	3800
Catalyst/Oil Ratio—Wt.	0.79
Space Velocity—Wt.	0.37

Product Yields	
Carbon—Wt. %	1.2
Dry Gas-Wt. %	11.6
Butanes—Vol. %	7.4
Reformate—Vol. %	77.6
F-1 clear	92.1

This unit has produced a reformate having 100 F-1 clear octane rating.

##

Meet the Author

ROBERT G. CHRISTOPHER, with The M. W. Kellogg Company since 1951, is senior process engineer in the company's Refinery Plans division. He previously was associated with Standard Oil Development Company as a research chemical engineer. Christopher holds a master's degree from Poltechnic Institute of Brooklyn. He is a member of ACS, AIChE and The Scientific Research Society of America.

PROCESS ISSUE '55
18th Annual

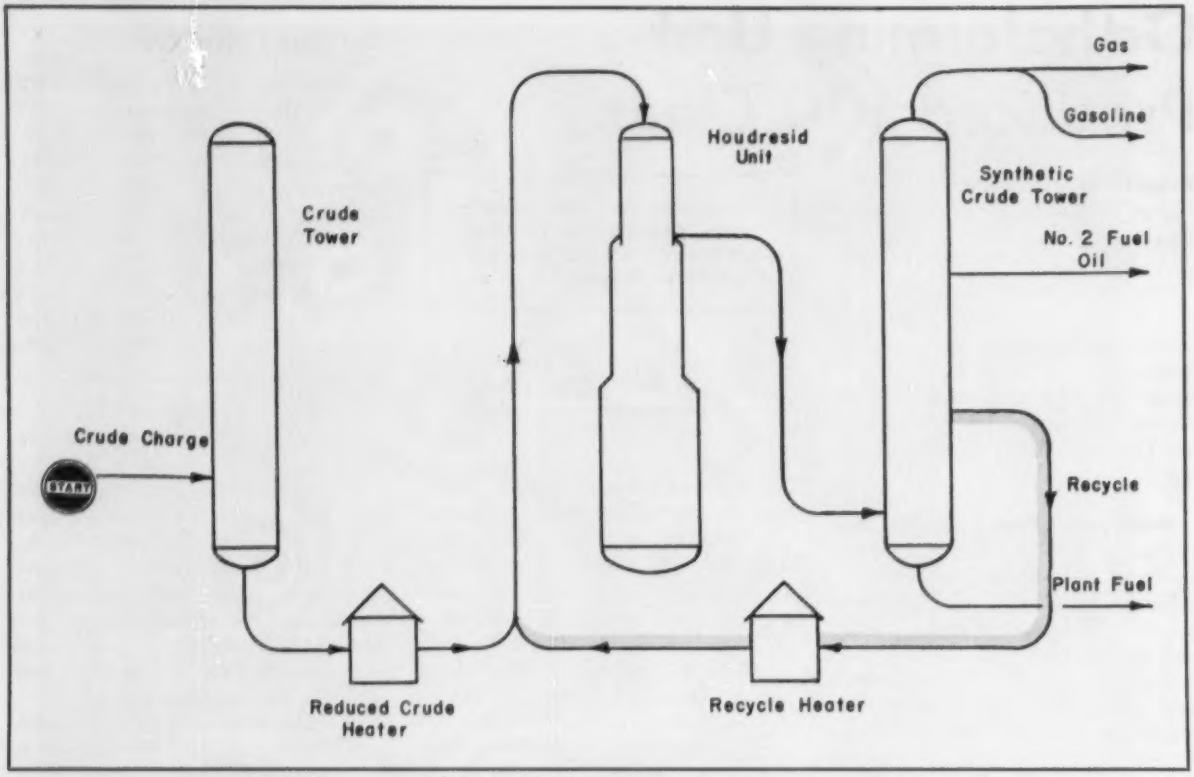


FIGURE 1—Flow diagram for Houdresid catalytic cracking: Heavy recycle gas oil is cracked to extinction.

HOW HOUDRESID WORKS ON HEAVY STOCKS

One year's commercial operation and pilot plant studies indicate that this catalytic cracking process experiences no trouble with heavy metal contamination.

Rophie E. Bland
Houdry Process Corporation
Philadelphia, Pa.

HOUDRESID catalytic cracking is a new, refinery-proved, continuous moving bed process by which exceptional yields of high-octane gasoline and light distillate fuels are obtained from reduced crude. Production of heavy residual fuel is thereby eliminated. The Houdresid process was announced in March, 1955, following a year's successful commercial operation.

Residuum cuts ranging from crude tower bottoms to vacuum bottoms, including residua high in sulfur or nitrogen, may be charged to the Houdresid unit, thereby permitting refiners greater flexibility in the kind of crude that may be run.

Either synthetic or natural clay catalyst may be used. Although the equipment required in Houdresid processing is similar in many respects to that employed in Houdriflow catalytic cracking, novel process features eliminate the adverse effects on catalyst and product selectivity heretofore resulting when heavy metals, such as iron, nickel, copper and vanadium, are present in the feed.

Table 1 shows comparative yields for Houdresid and conventional processing (vacuum distillation and catalytic cracking of vacuum gas oil) of the 50 percent bottoms of typical Mid-Continent crude mix.

Table 2 presents commercial Houdresid data at the beginning of operations in March, 1954, and approximately a year later, when processing the 50 percent bottoms from a mixture of Louisiana, Mid-Continent and East Texas crudes, at the Sun Oil Company, Ltd., refinery, at Sarnia, Ontario, Canada.

In other accompanying data, pilot plant results are shown for Houdresid processing of long range, heavy and highly-contaminated residua, and a simplified flow diagram of the process is presented.

TABLE 1
Comparative Product Yields of Houdresid and Conventional Processing

	Houdresid Catalytic Cracking	Vacuum Distillation Followed by Houdriflow Catalytic Cracking
Charge (BPSD)		
50 percent Mid-Continent Mix Reduced Crude	8071	8071
Products (BPSD)		
Fuel gas (FOE)	450	478
Excess butanes	35	216
10# RVP gasoline	5151	4244
Including:		
Cat-poly	(799)	(519)
Butanes	(392)	(309)
No. 2 fuel oil	1818	1278
No. 5 or 6 fuel oil	1033	2285

TABLE 2
Houdresid Processing of Mixed Mid-Continent, Texas & Louisiana Crudes

Charge to Houdresid Unit (BPSD)	7364	10009
Reduced Crude	(5020)	(6410)
Recycle	(2344)	(3599)
Inspection of Charge:		
Gravity, API	26.9	
IBP	650	
50 Percent	804	
EP	1066	
Sulfur, wt. percent	0.47	
Ramsbottom Carbon, wt. percent	3.0	
Nickel as metal, ppm	4.6	
Vanadium as metal, ppm	6.1	
Iron as metal, ppm	9.4	
Yields (Based on Fresh Feed):		
Conversion, vol. percent	67.6	67.6
Debutanized gasoline, vol. percent (385° F., at 90 percent)	48.5	51.6
No. 2 fuel, vol. percent	25.4	23.0
No. 6 fuel, vol. percent	7.0	9.4
C_4 cut, vol. percent	14.8	13.1
Dry gas, wt. percent	10.3	7.9
Coke, wt. percent	7.1	5.9
Hydrogen, SCF/Bbl. Residuum Converted	129	138
Inspection of C_5+ Gasoline:		
Octane, F-1 clear	93.0	91.6
RVP	6.0	6.2
Sulfur, wt. percent	0.08	0.08
Calculated Debutanized Gasoline Plus Polymer Gasoline, Vol. Pct.	58.6	60.3
Octane, F-1 clear	94.7	93.2
Calculated Total 10-lb. RVP Gaso., Vol. Percent	62.8	64.3
Octane, F-1 clear	95.2	93.7

Meet the Author

ROPHIE E. BLAND has been with Houdry Process Corporation 22 years.

Following graduation from Texas A&M College, he joined Sun Oil Company at Marcus Hook, Pa., and in 1933 helped install pioneer Houdry catalytic-cracking equipment for Sun. Moving to the Houdry organization, he worked on the development of synthetic catalyst and supervised batch preparation of the original synthetic catalyst as a forerunner to the designing of a commercial catalyst-production plant. He began assistant manager of development in 1940, later served as manager of the Project Analysis group and finally as sales manager.

Process Description—The Houdresid catalytic reactor and catalyst regenerating kiln are contained in a single vessel, structurally rugged and providing an optimum catalyst flow pattern.

Refinery crude tower bottoms, plus recycle gas oil from the synthetic crude tower, after heating are charged to the top of the Houdresid vessel in a partially vaporized state, mixed with steam.

As in Houdriflow units, the mixed-phase feed enters the reactor through a nozzle, and the charge is distributed over a flowing curtain of catalyst surrounding the nozzle. Vaporization of oil occurs on contact with the catalyst, and cracking proceeds as the catalyst and vapors flow downward through the reactor.

At the bottom of the reaction zone, vapors are separated from the catalyst and then flow to the synthetic crude tower, to be separated into wet gas, unstabilized gasoline, light gas oil, recycle gas oil, and synthetic tower bottoms.

Internal reflux within the syn-tower is controlled by adjustment of heat removal by way of quench oil circulation, side circulating reflux and tower top reflux. Heat is recovered from the circulating hot quench oil stream.

Wet gas and raw gasoline are processed in the gas plant to produce stabilized C_5+ gasoline, a C_3—C_4 stream rich in unsaturates, and fuel gas.

Light catalytic gas oil from the stripper is pumped through cooling to storage. Recycle gas oil is mixed with fresh feed and is cracked to extinction. Heavy catalytic gas oil (synthetic crude tower bottoms) is pumped through cooling to storage, and is suitable for use as No. 5 or No. 6 fuel oil.

The C_3—C_4 stream moves to the catalytic polymerization unit where cat-poly gasoline, butanes and fuel gas containing propane are produced.

Design Features—The Houdresid reactor shell is of uniform diameter through the main reactor zone but is swaged outward above the disengager to the diameter of the regenerating kiln. This provides an annular plenum chamber between shell and disengager skirt. The vapor disengager consists of a three-level channel assembly traversing the reactor area.

In the purge zone is a tube sheet pierced by short pipes in concentric circles. Purge steam is admitted below the tube sheet and flows upward through purge nipples, countercurrent

PROCESS ISSUE '55
18th Annual

to the flow of catalyst. Steam strips residual hydrocarbons from the moving catalyst, and joins the cracked vapor stream from the reactor.

Seal pipes mounted in a dished head extend from below the purge zone to the top of the kiln, serving as a pressure seal between the purge section and the top of the kiln.

No internal structures are required between the seal pipes at the top of the kiln and the air inlet caps at the bottom. After-burning does not occur. The use of a large excess air flow offers unusual flexibility in controlling kiln operation to handle high coke loads.

At optimum operating conditions, the entire amount of heat released by combustion of coke in the regenerating kiln can be absorbed in the catalytic reactor to provide heat of reaction and to satisfy sensible heat effects.

High heat capacity of the circulating catalyst stream assures stable operation of the heat-balanced unit. Normal variations in charge stock or in operating conditions result in only minor variations in catalyst temperature.

Heat-balance flexibility is provided by the charge preheater, an airline burner normally used only for startup, and by variation of catalyst circulation rate should there be major changes in operating conditions.

The pressure at the top of the kiln is low, permitting use of a single-stage blower (5 pounds per square inch gauge discharge pressure) for regeneration air. Catalyst circulation and catalyst regeneration may be continued while the reactor is by-passed.

TABLE 3
Houdresid Processing of Long Range Residua

CHARGE STOCK	40 Percent East Texas Reduced Crude	27.5 Percent South-Central Texas Mixed Reduced Crude
Gravity, °API	22.7	22.7
Sulfur, Wt. Percent	0.52	0.54
Nitrogen, Wt. Percent	0.17	0.11
Ramsbottom Carbon, Wt. Percent	4.5	2.8
Nickel as Metal, ppm	7.5	7.0
Vanadium as Metal, ppm	2.5	5.0
Yields, Percent of Fresh Feed	Once-Through	Once-Through
Debut, Gaso., Vol. Percent	44.3	40.5
Cat. Gas Oil, Vol. Percent	39.7	44.1
C4's, Vol. Percent	13.8	11.0
Dry Gas, Wt. Percent	7.9	9.5
Coke, Wt. Percent	6.9	6.2
Inspections of C5+ Gasoline:		
F-1 Clear Octane	91.6	94.1
Sulfur, Wt. Percent	0.06	0.11

TABLE 4
Houdresid Processing of Heavy Residua

CHARGE STOCK	10 Percent Mixed Mid-Continent, Texas and Louisiana Reduced Crude	10.6 Percent South-Central Texas Mixed Reduced Crude	4.1 Percent South-Central Texas Mixed Reduced Crude
Gravity, °API	12.6	17.7	12.7
Sulfur, Weight Percent	0.91	0.72	1.02
Nitrogen, Wt. Percent	....	0.20	0.36
Ramsbottom Carbon, Wt. Percent	12.4	5.3	14.0
Nickel as Metal, ppm	18.8	18.2	47
Vanadium as Metal, ppm	7.4	13.0	33
Yields, Percent of Fresh Feed	Once-Through	Once-Through	Once-Through
Debut, Gaso., Vol. %	40.1	42.6	40.4
Cat. Gas Oil, Vol. %	40.2	37.0	27.1
C4's, Vol. Percent	10.4	13.1	15.6
Dry Gas, Wt. Percent	7.3	11.6	13.5
Coke, Wt. Percent	16.3	8.5	17.6
Inspections of C5+ Gasoline:			
F-1 Clear Octane	89.3	93.4	90.7

Catalyst Circulation—Moving catalyst, delivered at the top of the reactor by the Houdry patented pneumatic lift system, is disengaged from lift gas and flows from hopper into reactor against a countercurrent flow of steam introduced at the base of the seal leg of the reactor chamber.

Catalyst enters the reactor from an inner head. About 80 percent of the catalyst flows down a vertical pipe in the head to the cracking zone, to which it is admitted by the annular orifice surrounding the feed nozzle. The remaining 20 percent of catalyst enters the cracking zone through a circle of pipes near the periphery of the vessel.

Catalyst flows downward in a solid moving bed through the vapor disengager section, and into the purge zone where countercurrent steam strips residual oil from the catalyst. The flow is then from purge nipples to seal pipes. A disengaging surface for flue gas and seal steam is formed by the catalyst flowing from the seal pipes.

Flowing downward through the kiln, catalyst encounters upward moving air introduced by a single-stage blower through inlets at the bottom. Coke burning is accomplished with minimum volume requirements.

After regeneration, catalyst is collected in pipes leading to concentric cones feeding the catalyst uniformly to the outlet pipe at the bottom. Catalyst then flows to the pneumatic lift system, is elevated to the top of the unit, and the cycle repeats.

A portion of flue gas is compressed by steam in thermocompressors to serve as the catalyst lifting medium. A smaller portion is used for catalyst fines removal in an elutriator.

Storage vessels for fresh and hot catalyst are provided. To unload the unit, hot catalyst is diverted to the storage hopper through a line from the lift disengager. Entire catalyst inventory may be held in this hopper during inspection and turnaround.

Summary—The Houdresid process, available through Houdry Process Corporation for general licensing to the refining industry, enables refiners to crack crude residua catalytically. The process is well adapted to the use of synthetic or natural clay catalyst, and to the charging of a wide range of reduced crudes.

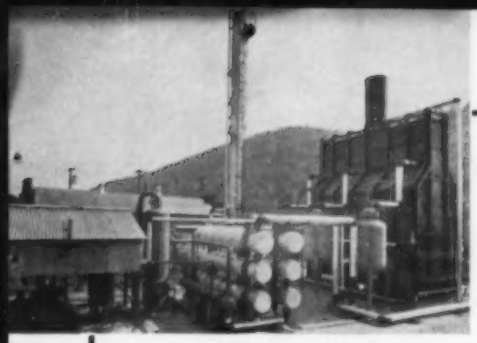
Pilot plant results and a year's commercial refinery operation demonstrate that the problems of heavy metal contamination heretofore inimical to catalytic cracking of residua have been successfully overcome by the Houdresid process.

One Houdresid unit has been in daily refinery production for over 18 months, and two other large units recently placed on stream are equipped for both Houdriflow gas oil and Houdresid bottoms catalytic cracking.

##

TABLE 5
Houdresid Processing of Residua Containing High Contaminant Concentrations

CHARGE STOCK	Ordonez Topped Crude	Boscan Topped Crude	Heavy Wyoming Reduced Crude		Kuwait Vac. Bottoms
Gravity, API	12.3	7.7	12.2		9.7
Sulfur, Wt. Percent	3.72	4.96	3.48		5.03
Nitrogen, Wt. Percent	0.42	0.70	0.38		0.33
Ramsbottom Carbon, Wt. Percent	13.3	10.4	11.8		16.7
Nickel as Metal, ppm	44	74	37		42
Vanadium as Metal, ppm	242	1000	76		98
Yields, Percent of Fresh Feed	Once-Through	Once-Through	Once-Through	Recycle	Once-Through
Debut Gaso., Vol. Percent	29.2	33.9	31.1	48.2	37.1
Cat. Gas Oil, Vol. Percent	49.6	43.8	44.5	26.1	34.6
C4's, Vol. Percent	7.0	7.0	10.6	10.1	9.6
Dry Gas, Wt. Percent	9.8	8.8	10.4	12.3	9.7
Coke, Wt. Percent	1.51	18.6	15.2	18.2	22.1
Inspections of C5+ Gasoline:					
F-1 Clear Octane	90.3	92.1	91.8	93.0	88.9



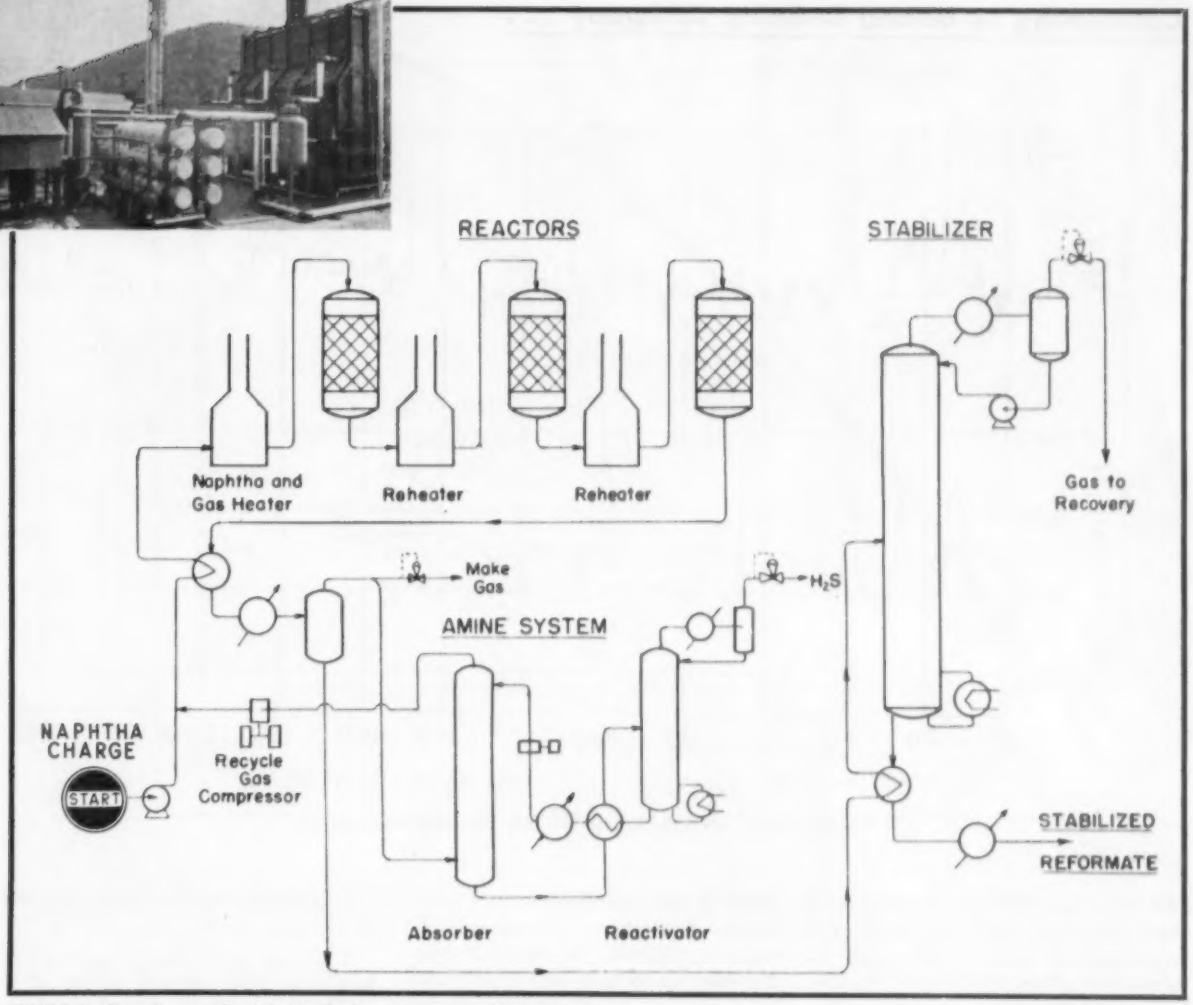


FIGURE 1—Flow diagram for Atlantic Catforming process: Amine unit desulfurizes hydrogen recycle. Photo is United's Catformer at Warren, Pa., in operation since 1953.

CATFORMING at United Refining Company

Testing ♦ Start-Up ♦ Shutdown ♦ Regeneration ♦ Operating Results

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B. E. Milner
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A 2500-BARREL-per-stream-day Catformer, installed at the United Refining Company's refinery in Warren, Pa., in August, 1953, has been the principal octane quality improvement process for their entire gasoline pool since that time. This unit was built by the Chemical Plants Division of Blaw-Knox Company and is operated under license from The Atlantic Refining Company.

The unit is a standard Catformer with an amine unit included to desulfurize the recycle hydrogen stream. The general process flow is shown in Figure 1. Since the flow has been described previously, it will not be repeated here. However, a few notes on the specific equipment items employed may be of interest. Charge stock to the unit is a full boiling range straight run naphtha taken overhead from two pipe stills. This raw naphtha passes through a clay bed and two fibre filters to remove scale and rust before going into the Catformer. On an intermittent basis, up to 10 volume percent of the Uni-

PROCESS ISSUE '55
18th Annual

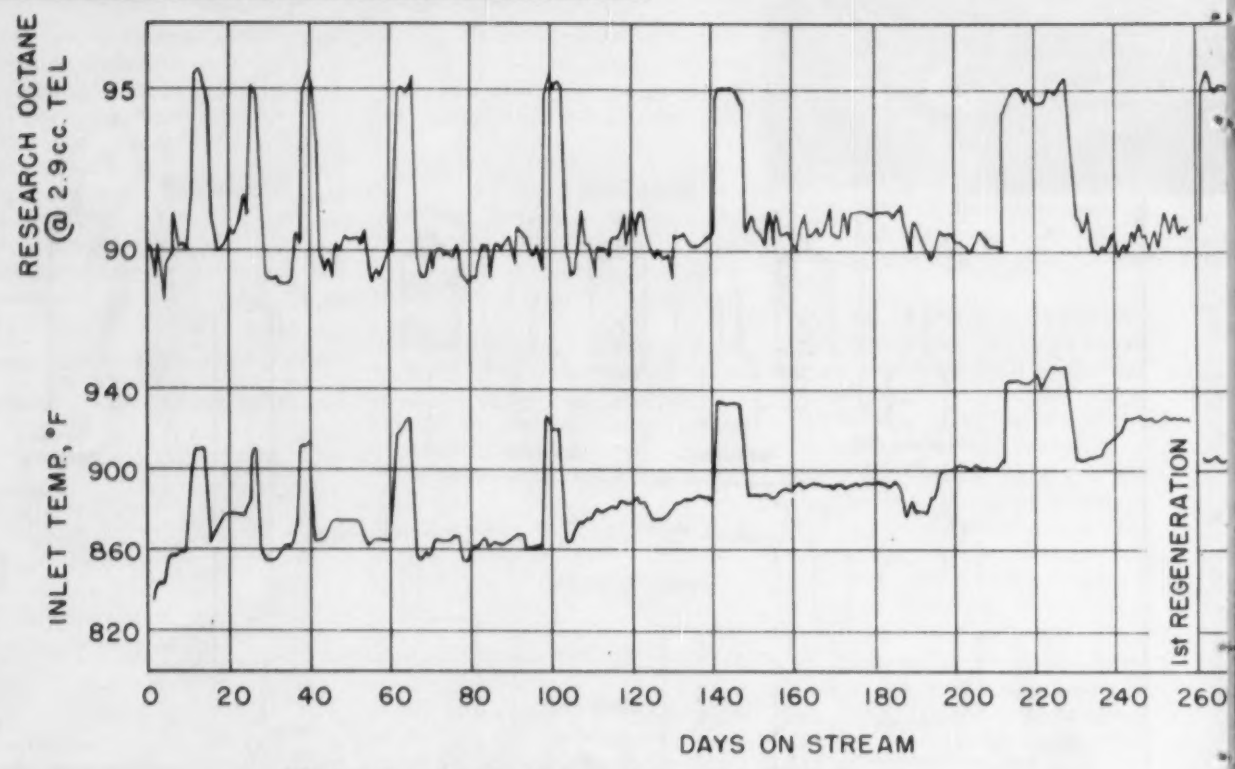


FIGURE 2—How reformate octanes vary with operating temperatures.

fined pressure distillate is included in the Catformer feed. The catalyst is contained in three equal sized, internally insulated down flow reactors. Process heat is supplied by a box type furnace, fired by oil with gas as a trim on the three separately controlled coil outlet temperatures. The three heating coils are housed in separately heated compartments in one furnace frame. One preheats the feed going to the first reactor and the other two successively smaller coils reheat the process stream between reactors. Hydrogen recycle flow is maintained by two electric drive compressors with a third steam driven stand-by spare. The three compressors are each of 200-bhp rating and are the conventional lubricated type designed for hydrogen service.

An amine system removes H_2S from the recycle gas stream to minimize the sulfur concentration in the reactors. The system consists of an absorber and reactivator for stripping H_2S from the amine solution. No drying or other clean-up of the scrubbed recycle gas is required.

The stabilized reformate goes directly to gasoline blending. At United, where Catformate constitutes the major component in the total gasoline pool, catforming severity is varied as desired to fulfill octane requirements of both premium and regular grade gasoline products.

The entire unit is instrumented for automatic control.

By-product hydrogen produced by the Catformer is used to Unifine middle distillates and a small quantity of pressure distillate. This 750-bpsd Unifiner, licensed by Union Oil Company, was the first commercial unit to be operated.

Preliminary Testing of Unit—Testing of a Catformer unit prior to start-up goes forward concurrent with the final stages of construction and has about as few steps as there are components in the unit. This testing is principally dictated by design operation conditions, which for the United Catformer were: 500 to 700 psig pressure at the middle reactor; 10/1 recycle gas ratio, moles of recycle gas/mole of fresh feed; and 850 to 975 F. reactor inlet temperature.

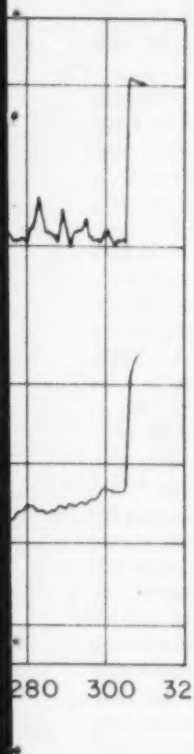
Preliminary testing, then, includes these items:

1. Vessels and transfer piping are hydrostatically pressure tested after fabrication.

2. The naphtha feed pump and recycle gas compressors are run in for six to twenty-four hours after installation to check out any flaws in assembly, mounting and instrumentation.

3. The entire high pressure system is gas tested to see that there are no leaks. This is done by pressuring with air or preferably sweet natural gas to near operating pressure using a small test compressor or the recirculating compressors temporarily hooked in series. The flanged joints and closures in the high pressure system are all ring sealed. These may best be tested for leaks by taping with masking tape, then leaks are readily shown by applying soap solution to a small puncture in the masking tape. All flange joints are usually tightened with hammer wrenches.

4. Gas circulation is then started by means of the recycle compressors, the



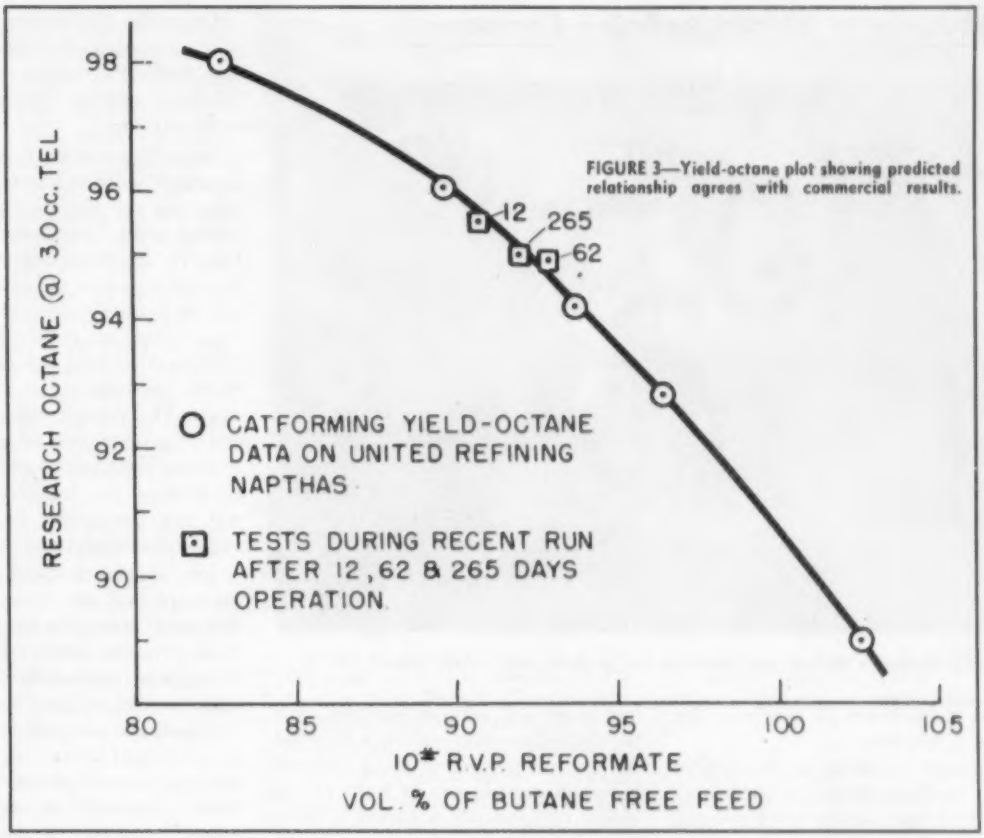


FIGURE 3—Yield-octane plot showing predicted relationship agrees with commercial results.

furnaces are fired and both furnace insulation and reactor insulation is cured as directed by the fabricators. During this initial circulating period, which may be 36 to 48 hours in duration, temperature, pressure and flow indicators and control instruments, including furnace firing controls may be checked. Reactor vessel insulation can also be checked at this time.

5. The amine system may be charged with solution at this time and the circulating system checked.

6. Other instruments, operational or safety in nature (liquid level controls, flow controls, high liquid level or low recycle flow alarms and cut-outs) are checked.

7. Emergency behavior of instruments and alarms, instrument air failure, power failure, etc. are rechecked on all instrument actuated controls.

8. Off site tie-ins, charge and product lines, flare line, cooling water and other utilities are checked.

Start-Up Procedure—Following the preliminary testing and curing of reactor and furnace linings, and tightening of all leaks, the unit is ready to start.

Catalyst is first loaded into the reactors. A support for the catalyst bed is built up with refractory alundum balls graded in size from ¾ to ¼-inch and built up to cover the collecting nozzles at the reactor outlets. The catalyst beds themselves are topped with stainless steel screens and then three to five-inch layers of ¾-inch alundum balls.

After resealing the reactor heads the high pressure system is made ready for hydrogen pressuring. This is done by first minimizing the oxygen content in the high pressure system by evacuating it with the steam eductor provided. A vacuum of about 25 to 27 inches of mercury is pulled on the entire system, including compressors and amine unit absorber tower. The eductor is then shut off and the vacuum released by charging hydrogen to the system. An alternate precautionary step may be to first release vacuum with nitrogen to further displace air in the system, then re-evacuate and then introduce hydrogen. When a positive pressure is reached the amine tower may be blocked off and the rest of the system pressured to about 150 psig with hydrogen. Circulation of hydrogen is started by means of the compressors, the furnaces are fired and catalyst given an initial hydrogen "conditioning" by bringing the reactor inlets to operating temperature and holding for a short time.

Inlet temperatures are then lowered to start-up temperature, the system pressure is brought to a minimum of 200 psig by hydrogen addition and naphtha flow is then started. Purchased hydrogen is used in the initial start-up, then process hydrogen is stored for future startups. At first, naphtha flow is at half rate, then as hydrogen is produced and system pressure rises quickly to operating pressure, naphtha flow is increased to full rate. As system pressure reaches the desired level, it is held constant by venting make gas from the high

PROCESS ISSUE '55
18th Annual

FIGURE 4—During start-up, gas detector is used to check leaks in high-pressure system.

pressure flash drum by means of the pressure controller.

Reformate builds up to the desired level in the flash drum and then flows to the stabilizer under level control.

The stabilizer, reboiled with steam, is then brought into operation in conventional manner to produce the desired RVP product. As full naphtha flow may be reached quickly, it takes but a short time to build up levels in the flash drum and stabilizer. Hence, the unit is brought on stream in but a very short time (one to two hours). Temperatures of reactor inlet streams are then brought under close control and gradually moved upward checking reformate octanes enroute, until the desired product quality is attained. As the run progresses using properly balanced recycle gas to fresh charge ratios, temperature is varied to offset changes in feed stock or slow change in activity to produce desired reformate octanes.

During and immediately after the start-up, as time permits or operation dictates, a careful check is made over the entire high pressure system for leaks. A gas detector is helpful in testing for leaks when the unit is in operation. A further check is made of reactor shell temperatures for proper temperature of operation.

Once the Catformer is on stream and producing hydrogen rich make gas, hydrogen storage vessels may be filled to provide hydrogen for the next start-up.

Smooth operation is best assured by regular scheduled attention to the filter elements on the naphtha feed and checking the compressor valve assemblies for accumulation of dirt or construction waste (welding slag). An aid to maintaining a clean feed and longer filter life is the use of corrosion inhibitors such as the organic amines in the naphtha coming off the crude units. The compressors may be taken out of service, one at a time by substituting the spare in recycle service or by backing out feed naphtha to permit one compressor to maintain the required minimum recycle flow ratio.

Servicing of the feed pump may be accomplished by stopping naphtha flow and closing the block valve to the high pressure system. Hydrogen circulation is continued with reactor inlet temperatures reduced and block valves in liquid and gas products lines closed. If prolonged delays in naphtha flow are encountered, the unit may be shut down (furnace fires and compressors stopped) after circulating down to 100 F. or more below reaction temperatures and can be left under hydrogen pressure.

Shut Down Procedure—In the normal course of operation the Catformer may be shut down or taken off stream to effect catalyst regeneration, to change catalyst or to inspect or service elements in the high pressure system.

Shut down procedure consists of: (1) stopping naphtha flow; (2) cutting furnace fires and circulating down to reduced temperature; (3) venting system pressure to a flare; and (4) purging system free of combustible gases.

The reduction of system temperatures and purging of combustible gases will vary with the objective of the shut down. To effect a regeneration the system will be cooled to about 600 F. and steamed briefly to purge sufficiently to permit making the steam, air and flue connections to the regeneration system. If catalyst is to be changed or the unit cooled down completely for mechanical inspection, hydrogen circulation is continued until the catalyst beds are cooled down below 200 F., pressure is vented,

TABLE 1
United Refining Company
Charge and Product Inspections

	Feed	Reformate
API Gravity	64.8	62.7
RVP	11.0	10.4
Aniline Point	135	94
Bromine Number	1.7	...
Percent Sulfur	.035	<.001
ASTM Gum	<0.5	...
CFRR Clear	52.2	83.0
CFRR + 3cc	...	95.0
Volume Percent C_3	1.2	...
iC_4	1.4	1.0
nC_4	5.4	7.0
iC_5	4.1	11.0
nC_5	5.1	8.8
C_6^+ Paraffins	40.8	33.2
C_6^+ Naphthenes	35.6	8.6
C_6^+ Aromatics	6.4	29.8
ASTM Distillation:		
Over	88	87
10	145	119
30	203	156
50	243	194
70	282	242
90	337	307
End Point	389	372
Recovery	96.0	97.5

TABLE 2
United Refining Company
Light Hydrocarbon Yields and Separator Gas Composition

	Weight %	Volume %
H_2	1.02	...
C_1	0.33	...
C_2	1.10	...
C_3	7.49	...
iC_4	...	3.06
nC_4	...	2.73
iC_5	...	5.88
nC_5	...	2.67
C_6^+	...	84.6

Composition

	Primary Separator Gas
	89.8 Volume Percent
H_2	2.5
C_1	1.4
C_2	3.2
C_3	1.1
iC_4	1.3
nC_4	0.4
iC_5	0.2
nC_5	0.1
C_6^+	

the system evacuated by the steam eductor and then the vacuum is broken with nitrogen. The unit may then be opened and air admitted.

Regeneration Procedure—Regeneration of the catalyst is simply and quickly accomplished. After coming off stream and preparing for regeneration as indicated above, the regeneration connections are made. These consist of a steam and air connection ahead of the first furnace and a flue gas connection after the third reactor. The rest of the high-pressure system is blanked off. Steam flow of about 4000 pounds per hour is started and furnace fires are lighted and adjusted to give reactor inlet temperatures of 600 to 700 F. Air is carefully admitted to this steam flow and temperature points in the reactor beds carefully watched. A burning front passes successively through the first, second and third reactors as one to three weight percent carbonaceous deposit on the catalyst is burned away. Air flow is controlled to limit the temperature of this burning to a maximum of 850 to 900 F. As burning progresses, air flow is increased up to 1 percent oxygen in the stream and regeneration temperatures are finally raised to 950 F. Two thermocouple rods in each reactor with couples at top, middle and bottom of the catalyst beds permit close following of the regenerative burning front. CO_2 and oxygen analyses of the effluent gas stream serves as a further check on the progress of the regeneration. The regeneration itself is completed in six to twelve hours. With regeneration complete, the regeneration connections and blanks in the process lines are removed ready for start-up. The overall off stream time for regeneration is less than twenty-four hours.

Operation And Results—United is charging a full boiling range naphtha containing 15 to 17 volume percent C_5 and lighter components. They vary operating temperature and thruput to alternately produce Catformates for regular and premium gasoline blending. The variance in operating temperature and corresponding reformate octanes with 2.9 cc TEL over the course of their most recent run are shown in Figure 2. This run was made with a catalyst loading of but 75 percent of design. Charge rates varied from 1800 to 3000-bpsd as required by market outlets. The plot of operating temperature extends through operation following the first regeneration. The run was continued through a second regeneration, catalyst being changed at a thruput of about 99 barrels per pound and after 10½ months' use.

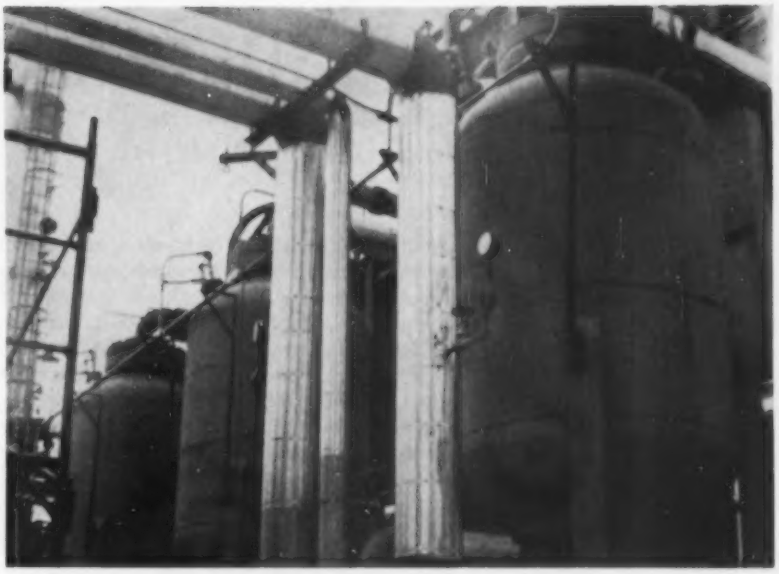


FIGURE 5—Three reactor cases: Each bed is topped with stainless steel screens and then three to five inch layer of alundum balls.

Feed and reformate inspections obtained in a test run following the first regeneration are shown in Table 1. Light hydrocarbon yields based on the debutanized portion of the feed are shown in Table 2, along with the composition of the primary separator gas.

A plot of yield-octane relationship predicted for Catforming United Refining naphthas is shown in Figure 3, along with points realized in commercial operation. The test data for actual operation after 12, 62 and 265 days operation on the same catalyst charge show no change in yield-octane relationship over this extended period. The last test was made after the first catalyst regeneration, and shows the same yield-octane relationship after regeneration as before.

Meet the Authors

Nevison Milner Logan

JOHN A. NEVISON, assistant head of Atlantic's Licensing section of the Research and Development department, is a chemical engineering graduate from Carnegie Institute of Technology. He has been with Atlantic since 1935, and was associated with major petrochemical developments prior to joining the newly-formed licensing group in 1953.

BYRON E. MILNER is head of the Licensing section of The Atlantic Refining Company. He holds a chemical engineering degree from the University of Pennsylvania and has been with Atlantic since 1939. Before organizing the company's licensing activities, he was engaged in process development with the Research and Development department.

HARRY A. LOGAN, JR., executive vice president of United Refining Company, is the son of H. A. Logan, president and founder of the company. A graduate of Princeton University, he was elected vice president of the company in 1952. He is a member of the board of directors of Pennsylvania Grade Crude Oil Association and a member of the General Committee of API's Division of Refining.

ULTRAFORMER TOPS

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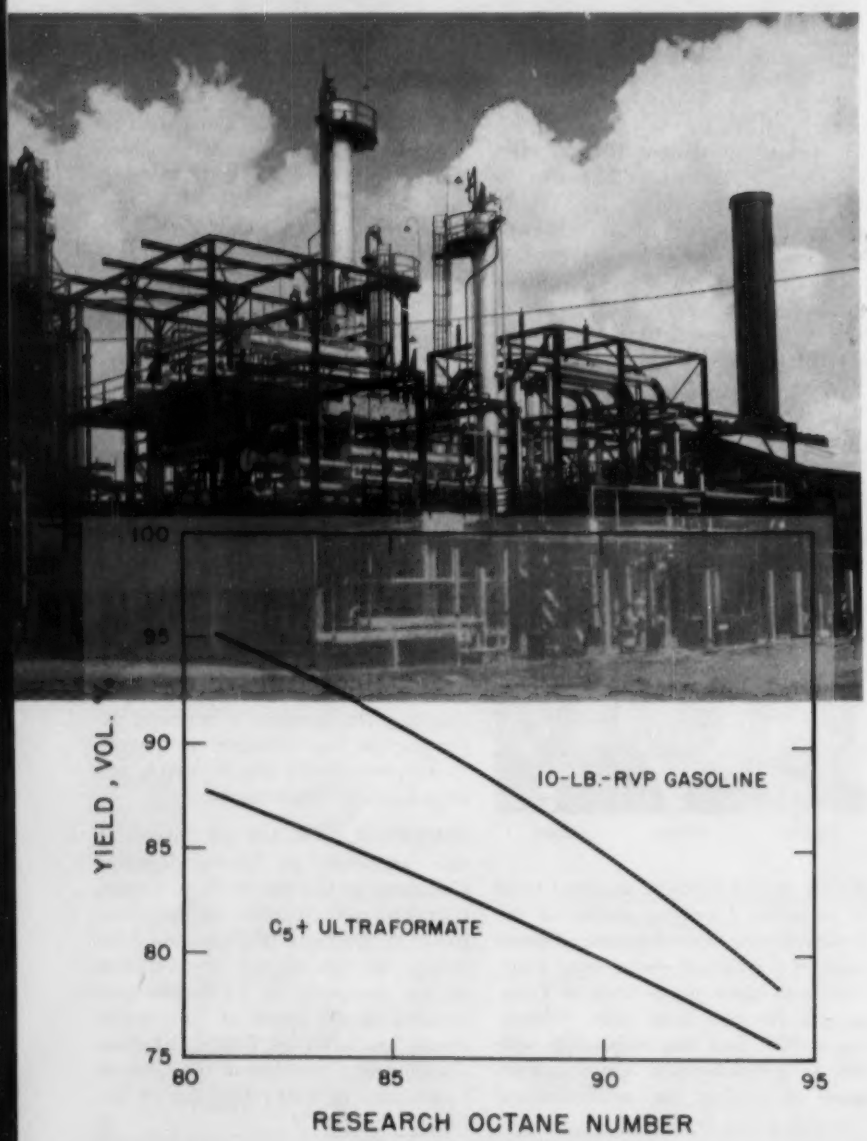
THE CONTINUING successful operation of Ultraforming units with a wide variety of feeds has established the process in the catalytic reforming field. Six units having a total capacity of about 80,000 barrels per day are now operating, three totaling about 23,000 barrels are expected to be in operation by the end of the year, and six more are scheduled for completion in 1956. The location and capacity of each of the units are given in Table 1.

Earlier papers have described the Ultraforming process.[1,2,3,4] Naphtha is processed in a series of reactors over a highly selective platinum-on-alumina catalyst at 200 to 300 pounds per square inch to give high-octane-number gasoline-blending stocks. Other operating conditions are: 900 to 970 F.; 1 to 4 space velocity; and 3000 to 6000 cubic feet of recycle gas per barrel of charge. Feeds containing more than about 0.03 percent sulfur are hydrodesulfurized to ensure optimum catalyst performance.



Because of the low pressure, small amounts of coke deposit on the catalyst, but periodic regeneration maintains high activity. Frequency of regeneration depends on operating conditions and feed properties; cycle length may vary from a week to several months. A swing reactor permits regeneration without interruption of processing; piping is such that the swing reactor may be substituted for any spent reactor, which is then valved into the regeneration manifold. Regeneration by the Ultraforming technique restores the catalyst to peak performance.

Five advantages result from the combination of high catalyst selectivity, low operating pressure, and the unique regeneration technique:

- High product octane levels without excessive cracking losses—especially important with paraffinic feeds.
- Long-term maintenance of high catalyst activity and product yields through restoration of full catalyst performance by regeneration.
- Flexibility to process a variety of feeds including those of high end point.
- Ready recovery from operating upsets.
- Start-up without hydrogen for pressuring.

These advantages have been thoroughly demonstrated in commercial operation.

EL DORADO

The first commercial Ultraforming unit was placed on stream in Pan-Am Southern's El Dorado, Ark., refinery in May, 1954. This unit is designed to process 6100 barrels per day of low-naphthene Arkansas naphtha to 90 research octane number, unleaded, using four reactors including the swing reactor. Because Ultraforming

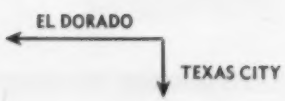
100 OCTANE . . . Texas City Unit—one of six now operating—produced over 100 clear octane reformate. Here's the story on the first six units.

catalyst was not yet available, a substitute catalyst was used during the first run. The unit operated smoothly until it was shut down for changing to Ultraforming catalyst in September, 1954.

For the second run, begun on September 18, the unit was started up with natural gas. Catalyst deactivation, which might be expected in the absence of hydrogen, was slight; regeneration completely restored catalyst activity. This run continued until a scheduled turn-around in March, 1955. Inspection showed the unit to be in good condition.

FIGURE 1 (left)—The data from the El Dorado Ultraformer show high yields.

FIGURE 2 (below)—Texas City ultraformer can produce a reformate of over 100 octane numbers.



The operation of the El Dorado unit points up the advantages of Ultraforming for upgrading of high-paraffin, low-naphthene feeds. El Dorado feed contains 70 to 80 percent paraffins, about 10 percent aromatics, and only 10 to 20 percent naphthenes. Economic reforming of such a naphtha requires that the paraffins be converted to aromatics, rather than hydrocracked. Ultraforming, by virtue of low operating pressure, effectively does so. Although the unit has usually produced 80 to 85 octane Ultraformate, adequate to meet present refinery needs, products rating above 95 octane number, unleaded, have been produced on occasion. Typical yields at the 85-octane level are shown in Table 2.

A yield-octane correlation covering the wide range of operations of the unit to date is presented in Figure 1. Yields of both 10-pound and C_5 + gasoline are substantially greater than could be obtained at higher pressures. The excellent 10-pound yields reflect both the increased yields of C_5 + gasoline and the larger volume of butane permitted by the low vapor pressure of the Ultraformates.

The flexibility of Ultraforming to handle operating upsets has been demonstrated at El Dorado. In one instance, a brief mechanical failure caused deposition of carbon on the catalyst and subsequent loss in activity; the catalyst was quickly regenerated and returned to peak activity. Similarly, because the Ultraformer can be easily shut down and brought back on stream, two minor cleaning and repair jobs were completed in about 24 hours each.

The catalyst in the El Dorado unit has thus far processed over 40 barrels of naphtha per pound. When inspected during the March turn-around it was as good as new. Catalyst life is expected to exceed 100 barrels per pound.

CASPER

Standard of Indiana's 3750-barrel Ultraformer at Casper, Wyo., is similar to the El Dorado unit except

LUMMUS

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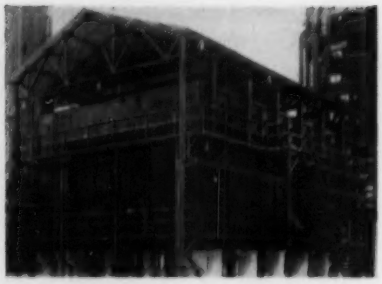
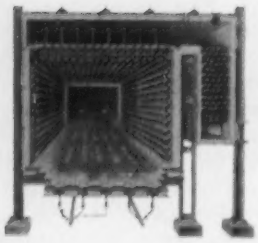
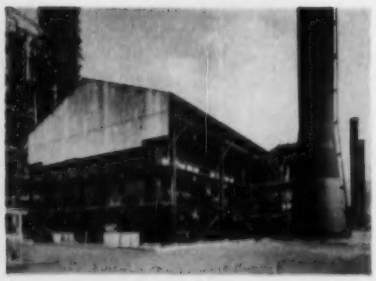
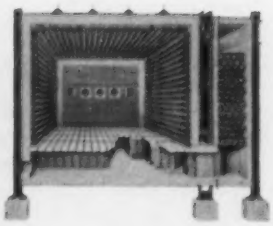


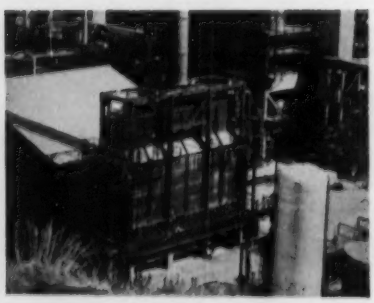


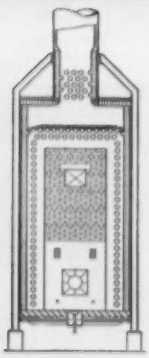
Lummus Standard Oil Heaters are made in two basic types. The up-take heater, illustrated at the left, conducts the products of combustion upward from the entire heating chamber at low and uniform levels of velocity.





The down-take heater, illustrated at the left, is suitable for service where products of combustion would contain corrosive elements or solid matter. It draws hot gases downward from the combustion chamber through the diffusion baffles. Both types of Lummus Standard Heaters are adaptable for multi-coil or multi-stage heating.





The Economy Heater, illustrated at the left, finds wide application in smaller refineries where the investment necessary for extensive maintenance platforms and roofing is not justified. The flexibility and variety of capacities available with multi-coil and multi-stage settings can be obtained with Lummus-Built Heaters in the same manner as with the larger Standard units.

Lummus Standard Oil Heaters and Lummus-Built Heaters are the answer to the vital problem of supplying process heat in any required amount for petroleum refineries, chemical and petro-chemical plants. Single Lummus Heaters are operating at continuous heat absorptions ranging from 100,000 to 300,000,000 BTU per hour. Lummus has designed and installed heaters for use with every major process.

BRANCH OFFICES — Houston: 2707 Weslayan Rd., Houston 6, Texas • England: The Lummus Co., Ltd., 80 Regent St., London W1, England • France: Societe Francaise des Techniques Lummus, 39 Rue Cambon, Paris ler, France

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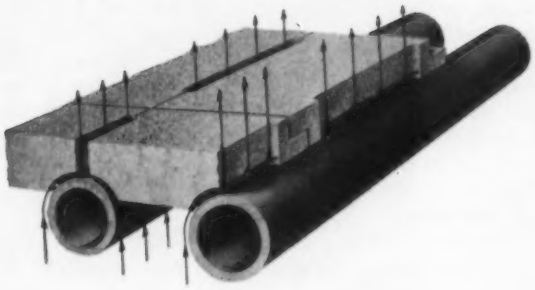
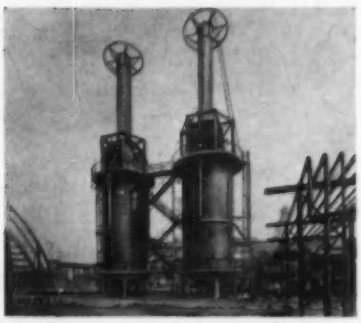


The patented gas diffusion baffle arrangement shown at the left is characteristic of Lummus furnaces. This arrangement creates a draft resistance or dampering effect which assures uniform evacuation of the products of combustion over the entire ceiling area of the combustion chamber.

Benefits obtained by the use of the slotted refractory baffle tile include high velocity gas flow over the shielded upper row of roof tubes—with consequent high convection heat pick-up—and re-radiated heat from the under side of the tile to the upper side of the bottom row of roof tubes.



Lummus-Built Heaters incorporate the same material, mechanical and operating advantages of the Lummus Standard Oil Heaters but are built along the more simplified and economical lines possible with their smaller size. The Lummus Vertical Tube Heater, illustrated at the left, for milder heat requirements, is especially designed for limited space installation.

The portable heater, left, was built for Magnolia in record time—a mere six weeks downtime compared with the usual five months. It is the height of flexibility and is a smooth-running 100,000,000 BTU per hour heater handling 36,000 B/D of charge stocks—an increase of several thousand barrels over the heater it replaced.

The heaters described above are, of course, Lummus designed. Lummus also has built and will build for you, if requested, counter-parts of all popular types of furnaces used in the petroleum, chemical and petro-chemical industries. Lummus can also build to your specifications any type of specialty heater that a particular production problem calls for. Lummus' 50 years of experience in constructing petroleum and chemical plants lies behind the work of the Oil Heater Division, providing the knowledge necessary to do any job requested by a customer—and to do it right.

BRANCH OFFICES — Chicago: 600 South Michigan Ave., Chicago 5, Illinois • Venezuela: Compania Anonima Venezolana Lummus, Edificio "Las Grandillas", Esquina Las Gradillas, Caracas, Venezuela • Canada: 455 Craig St. West, Montreal

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Tops 100 Octane . . .

Meet the Author

T. M. MOORE is in charge of field services work on Ultraforming for Standard Oil Company (Indiana). He joined Standard's research staff in 1946, and for three years headed a group handling pilot-plant development of the Ultraforming process. A graduate of Illinois Institute of Technology, he holds a bachelor's degree in chemical engineering. Moore is a member of AIChE.

that it has a cobalt-molybdenum hydrodesulfurizer to handle Casper's high-sulfur naphthas. The unit was started up in December, 1954, with natural gas; the desulfurizer was bypassed until sufficient hydrogen was produced to operate it. Since then, the desulfurizer has been in operation most of the time, without regeneration. No appreciable loss of desulfurization activity is apparent.

Operation has been steady at 70-75 octane number—high enough to meet present refinery needs. However, during a test program 90-octane Ultraformate was easily produced. Because of the mild operating conditions, regenerations have been infrequent.

The Casper unit has furnished another example of the ease of shutting down and starting up Ultraformers. When the refinery was forced to curtail operations for a short time because of a power shortage, the Ultraformer was chosen for shutdown in preference to other units.

TEXAS CITY

A striking example of the ability of Ultraforming to reach high octane levels is the operation of the American Oil Company's 21,200-barrel unit at Texas City, Texas. This six-reactor Ultraformer, shown in Figure 2, is designed for high-severity operation with frequent regeneration. No desulfurization is employed. Since being placed in service in February, it has reformed Gulf Coast naphtha of 400 F. end point to octane numbers ranging from 96 to over 100, unleaded. Typical feed inspections and product yields are given in Table 3.

This unit has demonstrated how Ultraforming can respond to changes in refinery demand. Original catalyst loading was fixed at two thirds of design, on the basis of the then-current octane target; however, a change in gasoline specifications forced a boost in octane level shortly after the unit was put on stream. The higher level was obtained without shutting down the unit to add catalyst by increasing reactor temperatures and the frequency of regeneration. Subsequently, catalyst loading was increased to the design level during a shutdown for minor mechanical repairs.

WOOD RIVER

Standard's 9000-barrel Ultraformer at Wood River, Ill., was brought on stream in April. This unit employs five reactors, including the swing reactor, in processing a Mid-Continent feed of 150-400 F. boiling range to octane numbers of 80 to 85. As in the Texas City unit, no desulfurization is employed. Although the unit is operating at design thruput, only 50 percent of design catalyst loading is being used because of the present low reformate-octane needs of this refinery.

Operation has been smooth and the catalyst has shown excellent response to the few regenerations so far required.

NEW INSTALLATIONS

Humble Oil & Refining Company has 40,000 barrels of Ultraforming capacity at Baytown, Texas. The company placed a new 20,000-barrel Ultraformer in service in June; operations have been smooth. Humble then converted its old fixed-bed molybdena hydroformer to a second Ultraformer. A unique feature of this installation is the use of modified regeneration facilities at the old unit for both ultraformers.

The Ultraformer of the Great Northern Oil Company at Pine Bend, Minn., will take full advantage of the hydrogen-producing potential of the process. Hydrogen produced in this 5000-barrel unit is used to desulfurize No. 1 and No. 2 fuel oils, as well as Ultraformer feed.

Both the Great Northern unit and Canadian Petrofina's 3600-barrel unit at Montreal are scheduled to come onstream this month. They will be followed in October by Standard's 14,000-barrel Ultraformer at Sugar Creek, Mo. Units scheduled for completion next year will bring total installed Ultraforming capacity to 146,150 barrels.

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[1] Steel, R. A., Bock, J. A., Hertwig, W. R., and Russum, L. W., PETROLEUM REFINER, 33, No. 5, 167 (1954).

[2] Birmingham, W. J., *Petroleum Engineer*, 26, No. 4, C-35 (1954).

[3] Forrester, J. H., Conn, A. L., and Malloy, J. B., Oil & Gas Journal, 52, No. 49, 139 (1954); PETROLEUM REFINER, 33, No. 4, 153 (1954).

[4] Roberts, J. K., Thiele, E. W., and Shankland, R. V., Paper presented before Fourth World Petroleum Congress, Section III/D, Rome, June, 1955.

TABLE 2
Typical El Dorado Ultraformer Data

Feed:	
Gravity °API	63.0
ASTM Distillation, F.:	
Initial	132
10 Percent	178
50 Percent	240
90 Percent	298
End Point	358
Composition, Volume Percent:	
Paraffins	71
Naphthenes	20
Aromatics	9
Products:	
C_5^+ Ultraformate:	
Yield, Volume Percent	84.2
Reid Vapor Pressure	6.1
Research Octane Number, Unleaded	85.0
10-Pound Reid Vapor Pressure Gasoline:	
Yield, Volume Percent	91.2
Research Octane Number, Unleaded	85.0
Research Octane Number, 3 cc TEL/gallon	96.5

TABLE 3
Typical Texas City Ultraformer Data

Feed:	
Gravity, °API	52.8
ASTM Distillation, F.	
Initial	185
10 Percent	247
50 Percent	292
90 Percent	348
End Point	399
Composition, Volume Percent:	
Paraffins	34
Naphthenes	52
Aromatics	14
C_5^+ Ultraformate:	
Yield, Volume Percent	80
Research Octane Number, Unleaded	97

TABLE 1
Present and Projected Ultraformers

COMPANY	LOCATION	Barrels/Day
Pan-Am Southern Corporation	El Dorado, Ark.	6100
Standard Oil Company (Indiana)	Casper, Wyo.	3750
American Oil Company (Texas)	Texas City, Texas	21,200
Standard Oil Company, (Indiana)	Wood River, Ill.	9000
Humble Oil and Refining Company	Baytown, Texas	20,000
Humble Oil and Refining Company	Baytown, Texas	20,000*
Great Northern Oil Company	Pine Bend, Minn.	5000
Canadian Petrofina, Ltd.	Montreal, Canada	3600
Standard Oil Company (Indiana)	Sugar Creek, Mo.	14,000
Standard Oil Company (Ohio)	Cleveland, Ohio	11,000
Leonard Refineries, Inc.	Alma, Mich.	3500
Utah Oil Refining Company	Salt Lake City, Utah	5500
Standard Oil Company, (Indiana)	Mandan, N.D.	6000
The Pure Oil Company	Smiths Bluff, Texas	15,000
Derby Oil Company	Wichita, Kan.	2500
	Total	146,150

* Conversion of fixed-bed hydroformer.

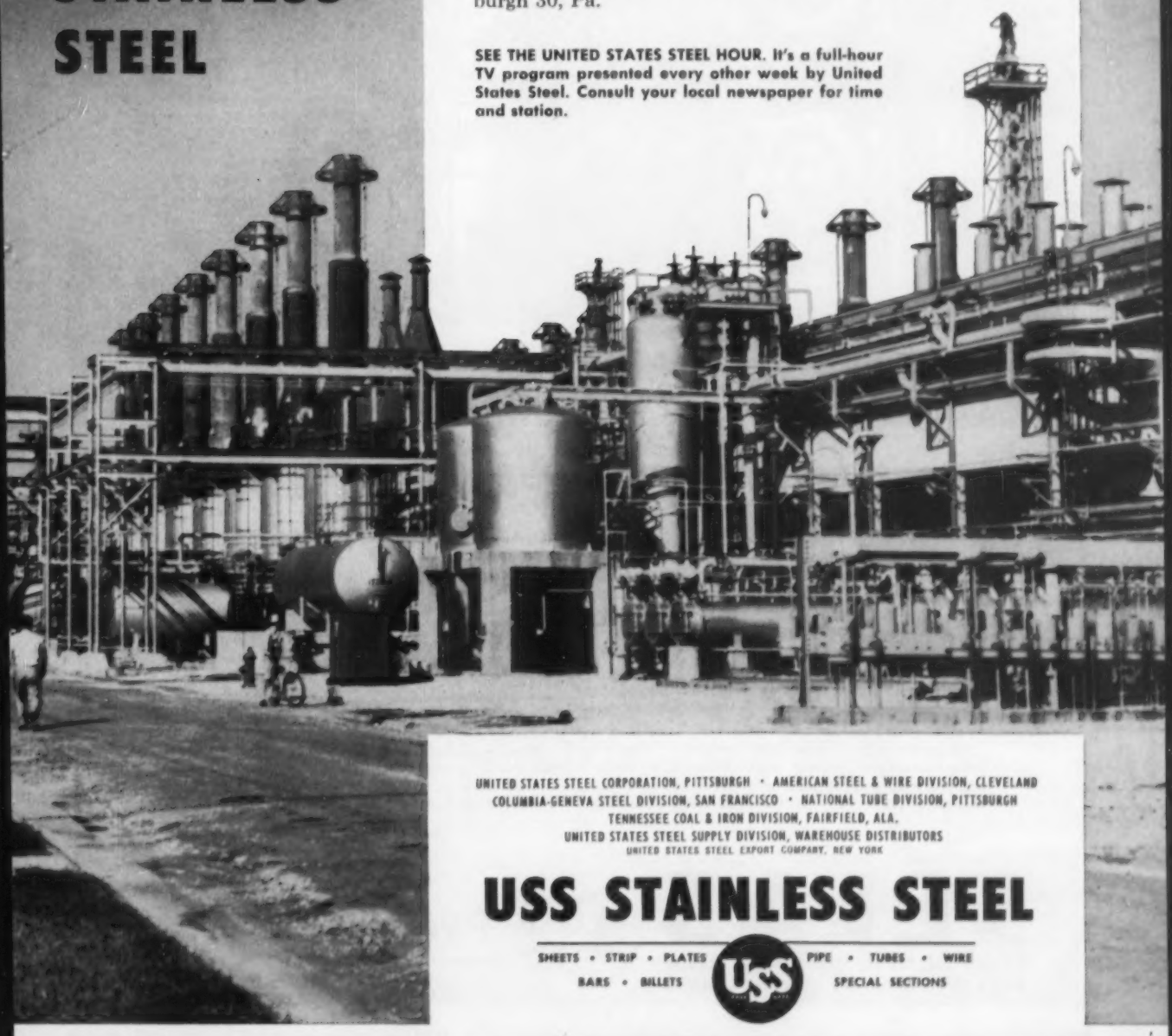
for styrene production

STAINLESS STEEL

To withstand the conditions that cause corrosion and oxidation in a big styrene plant, Stainless Steel was selected as the material for the tubes in these super heaters.

It's only one of many places where the vastly expanding petrochemical industry has met a problem of heat and corrosion with Stainless Steel. In USS Stainless Steel you have the widest variety of compositions for greatly varying applications. The ways in which USS Stainless Steel has met problems similar to those you may be encountering is described in our booklet "Performance of Stainless Steel in Petroleum Refinery Service." For your copy, write to United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.



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SELAS EQUIPMENT

Ethylene production by pyrolysis of light hydrocarbons—a 14-million Btu per hour Gradiation unit. Photo: Phillips Petroleum Co., Rice Plant, Borger, Texas.

Zone Control

GIVES Phillips 66 VERSATILITY

IN ETHYLENE PRODUCTION

Maximum product yield for any given feed stock . . . yet capable of handling extreme variations in feed stock . . . these are the outstanding features of Selas Zone Control in the production of ethylene at Phillips Petroleum Company.

Butane, propane or ethane are processed with equal ease at optimum conditions . . . through the same Selas Gradiation furnace . . . with exceptionally long runs. Average on-stream periods in excess of 60 days, at conversions of 65% ethane are obtained.

Other benefits of Selas Zone Control . . . whether your petroleum refining, petrochemical or chemical processing operations involve critical pyrolysis reactions, controlled catalytic reactions in packed tubes or high temperature preheating . . . are as follows:

- Uniform peripheral heat distribution around the tubes assures elimination of local overheating . . . minimized material degradation at the tube wall . . . greater tube life.
- Zones of controllable heat input produce the desired time-temperature curve . . . permit most effective use of the surface provided.
- Controlled combustion means no external oxidation of the tubes . . . no lag in response to controller demand.

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FLUID PROCESSING

SELAS

FOR FLUID PROCESSING

CONTINUOUS AUTOMATIC DRYING OF COMPRESSED AIR, PROCESS GASES AND LIQUIDS

Selas Dehydrators are designed for all conditions of processing, to effectively and economically dry gases and liquids.

Compressed air, carbon monoxide, hydrogen, oxygen, gaseous hydrocarbons, inert gases are dried efficiently.

Numerous liquids . . . including propane, butane, kerosene, benzol, toluene, xylene and solvent naphthas . . . are also dried.

- Desiccants employed are selected to meet moisture-removal requirements.
- Reactivation by steam, gas or electric heat.
- Operating pressures range from atmospheric to 6000 psig.

Selas Dehydrators are available for manual, semi-automatic and fully automatic operations. Capacities range to 15,000 scfm for gases, and up to 200 gpm for liquids.

Write for informative bulletin on "AIR-GAS PROCESSING."

Semi-automatic, continuous-duty Selas Dehydrator; capacity 14,500 scfm air at 150 psig.

Other SELAS Fluid Processing Equipment

LIQUID-GAS SEPARATION

Continuous automatic removal of water, water-oil emulsions and dirt from compressed air and process gases (nitrogen, hydrogen, oxygen, fuel gases); continuous automatic removal of condensate, oil, dirt and other impurities from steam. Available in capacities from 10 to 5000 scfm; pressures from 25 to 3500 psi.

HYDROCARBON VAPOR ADSORPTION ...*plus* LIQUID-GAS SEPARATION

Continuous removal of hydrocarbon vapors, liquid hydrocarbons, water-hydrocarbon emulsions and dirt from compressed air and process gases (nitrogen, hydrogen, carbon dioxide, inert gases). Available in capacities from 100 to 5000 scfm, at inlet pressures up to 3500 psi.

LIQUID-LIQUID SEPARATION

Continuous separation of emulsions in steam distillations, solvent extractions, organic reactions. Dewatering of solvents and hydrocarbons; recovery of organic liquids.

Capacities of single units range from 10 to 6000 gph.

For more data on advertised products, use Readers' Service Cards, last page.

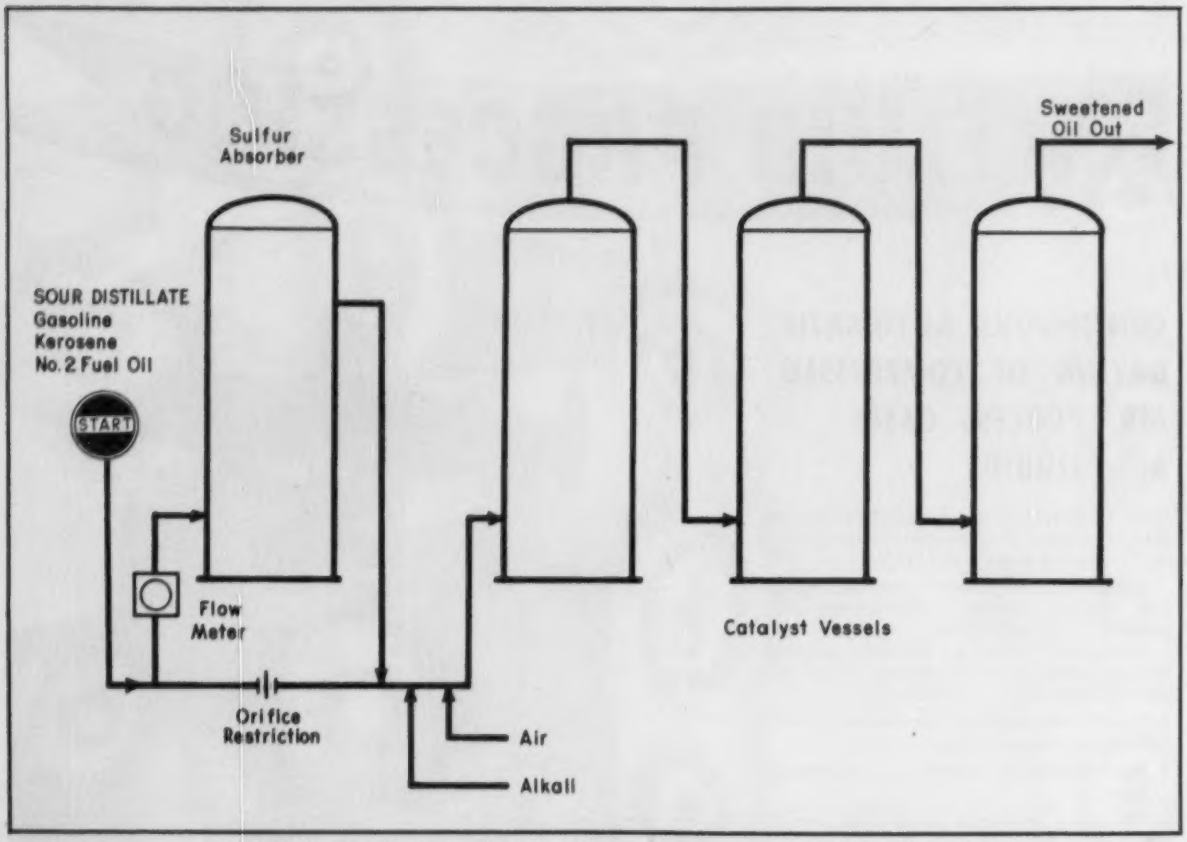

FIGURE 1—Flow diagram for Bender process: Installation costs vary from $10 to $20 per barrel.

BENDER PROCESS Sweetens at No Loss

Chemical cost is ½ cent per barrel; catalyst can be regenerated at plant site.

L. C. Waterman and R. A. Wiley
Petreco Division
Petrolite Corporation
Houston

THE BENDER PROCESS is utilized for sweetning gasoline, kerosine, jet fuel and No. 2 fuel, being especially applicable in the kerosine-No. 2 fuel range. Sweetening is effected by converting mercaptans to disulphide by oxidation.

In this process, sulfur is added to the distillate, plus a small amount of an alkali such as caustic or ammonia, plus air. This mixture is passed over a bed of solid catalyst, yielding a bright, sweet, non-corrosive product.

During the initial stage of the processing, sufficient additional sulfur is added to the distillate being treated to activate the catalyst bed. Thereafter, an equilibrium between lead oxide and lead sulfide is maintained in the treating system.

Throughput rates are relatively high for unit volume of catalyst. The distillate passes through the catalyst bed at rates up to 12-inches per minute. The amount of sulfur required ranges from ¼ to ¾ of the-

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Hand-tailored to any size you need...

...Goetze Heat Exchanger Gaskets are precision-made for longer service

Whether your requirements call for heat exchanger gaskets larger than 100″ in diameter, or smaller than 10″, you can get the exact size you want . . . hand-tailored to the shape you need . . . simply by specifying "Johns-Manville Goetze."

And because they're *precision-made*, you'll find these better gaskets provide the effective sealing and longer life that make them actually cost less in the long run. Each gasket is carefully constructed in every detail to assure accuracy of fit . . . to provide ample lap widths and uniform rib widths . . . and to prevent trouble-making wrinkles or cracks on the corners.

If you're having trouble with persistent joint leakage and frequent gasket replacements, find out how little it costs to have Goetze Heat Exchanger Gaskets tailored to your requirements. Your blueprint or template will bring a prompt estimate. Address Johns-Manville, Box 60, New York 16, New York.

Johns-Manville *Goetze* GASKETS

THERE'S A JOHNS-MANVILLE PACKING AND GASKET FOR EVERY SERVICE

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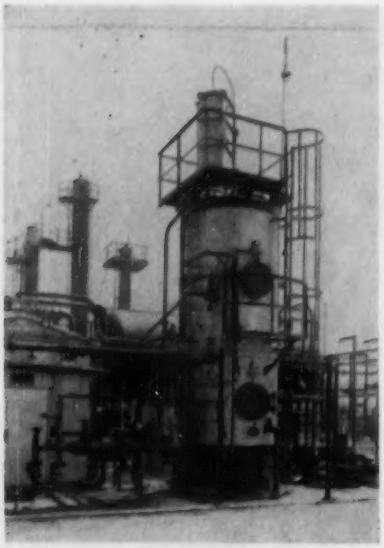

FIGURE 2—Two stage electrofining unit as used in naphthenic acid removal.

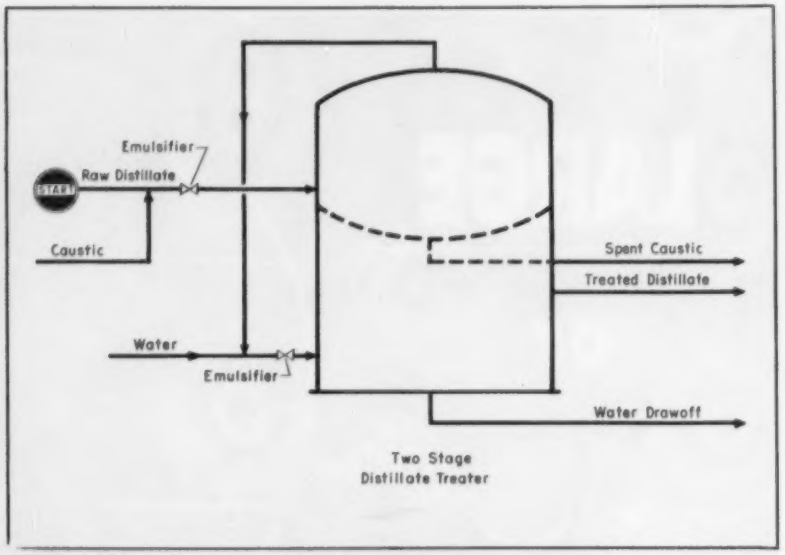

FIGURE 3—Flow diagram for electrofining naphthenic acid removal: Acid number of stove oil reduced to zero.

oretical sulfur equivalents. Just enough caustic is used to maintain the distillate in the effluent connection in a slightly alkaline state. Air requirements are moderate; it may be supplied from instrument air systems for the smaller size distillate streams. Electric precipitation equipment is scheduled for possible use in the caustic prescrubbers, and probably in the subsequent water washing stages, to reduce the sodium ion content of the distillate.

Installation costs for this process are estimated to be in the range of $10 to $20 per barrel per day of throughput. Chemical costs will run around .5 cent per barrel. One of the primary advantages of this process is the fact that there is no possible loss in the system, other than sampling and spillage. Regeneration is not required, operation is simple and only minimum operating attention is necessary. Catalyst life will vary, usually somewhere in a 6 to 12-months range. Rejuvenation of the catalyst can be accomplished economically and promptly at the plant site.

While the Bender process is not entirely new in that it has been used by Sinclair and its affiliates, the designation of Petreco as exclusive sublicensor will now make the process available to the entire industry.

First unit for Electrofining-Doctor treating . . .

The first commercial application of the Petreco electrofining process for doctor treating was made at the Co-op Refinery at Coffeyville, Kansas, in late 1952. This installation is the only continuous electric doctor treating plant in the world.

In this application of Electrofining to doctor treating, the doctor solution is continuously dispersed into a blend of straight run gasoline and thermally cracked gasoline. During the treatment the volume of chemicals used, the degree of dispersion and the time of contact are precisely and automatically controlled by instruments.

The mixture resulting from this dispersion is subjected to the action of the electric field, which coalesces the dispersed phase and separates the spent doctor solution from the gasoline. "Blackstrap" is removed continuously, resulting in more efficient spent doctor regeneration.

The plant at the Co-op Refinery treats an average of about 225,000 barrels per month. The efficient performance of the continuous, automatically-controlled treating results in substantial savings in lead, caustic, sulfur and inhibitor.

Compared with a conventional doctor treating operation, wherein the carry-over usually averages around 0.1 to 0.2 percent, the carryover in the Electrofining operation averages approximately 0.0015 percent. With this difference, the savings in doctor solution which would normally be lost to carryover average around 14.85 barrels per day.

In conventional doctor treating, volume losses frequently are substan-

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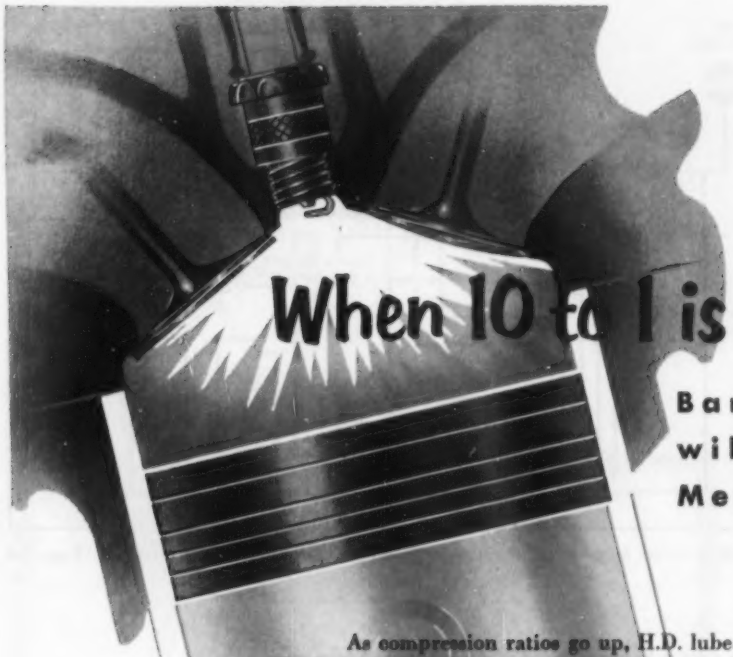

When 10 to 1 is Commonplace

Barium-Based Additives will provide an Extra Measure of Protection

As compression ratios go up, H.D. lube oils will undoubtedly be made obsolete by V.H.D. grades . . . formulated with still better barium-based additives.

Anticipating additive-makers' needs, we have been improving our electric-furnace barium reduction process to produce a very dense, crystalline material with particle size adjusted to users' requirements. As a result, additive makers can now achieve desired control of reaction rates.

Westvaco also pioneered flake Barium Octahydrate and Barium Pentahydrate—advanced forms of soluble barium values now widely used. These pioneering efforts continue. An advanced process developed by Westvaco engineers will soon bring you further benefits. Although we recently completed a 100% expansion of our facilities, we stand ready to again increase capacity should any eventuality require it.

When 10 to 1 is commonplace, better barium additives will be ready. As America's largest producer of barium chemicals, we shall continue to anticipate your needs.

if you are working with lube-oil additives, we would like you to have a copy of this new, 24-page booklet giving complete information on WESTVACO Barium Chemicals. Send for it now.

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Bender Process . . .

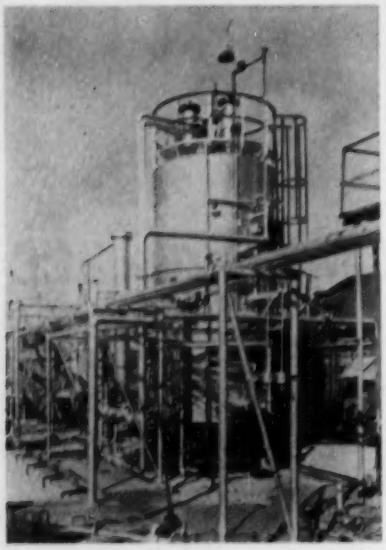

FIGURE 4—Doctor treating installation at Co-op Refinery at Coffeyville.

tial, often ranging from 0.25 to 0.5 percent. In the Petreco Electrofining-Doctor Treater the volume loss is approximately 0.05 to 0.1 percent, resulting in a saving of about 30.0 bpd on a 10,000 bpd stream.

The savings in chemicals alone pay for the plant rental, while the savings in volume losses, plant maintenance and operational attention result in a substantial profit for the refiner.

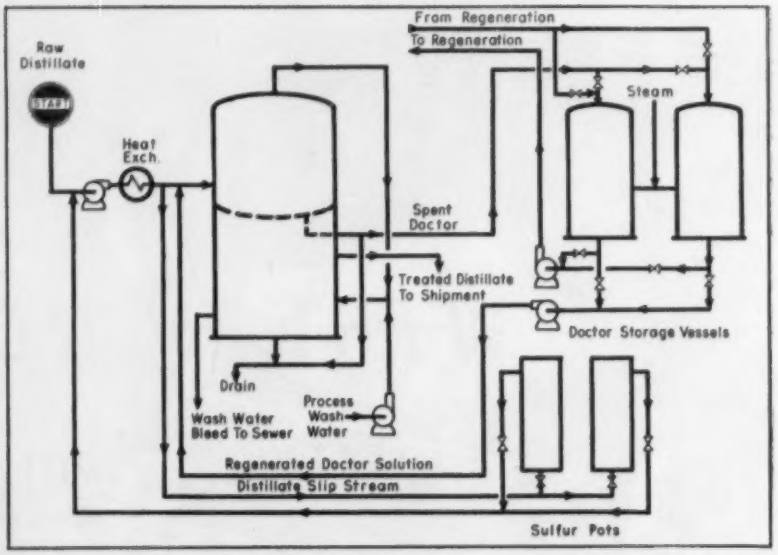

FIGURE 5—Flow diagram for Electrofining-Doctor treating. Carryover is only 0.0015 percent.

Electrofining for naphthenic acid removal . . .

A leading refiner in Canada now is installing Electrofining equipment for naphthenic acid removal from virgin distillates used for stove oil and gas oil. Electrofining will be utilized to caustic-scrub two distillate, streams one with an approximate API gravity of 42° and an acid number of about 0.25 and another with an approximate API gravity of 32° and an acid number around 0.5.

Pilot plant operations have demonstrated that the acid numbers of both streams will be reduced to 0.0 after Electrofining. This processing also will reduce the sodium ion content of both streams to 1 ppm or less. The efficiency of Electrofining also will prevent sedimentation, gum formation and color degradation in the finished stove oil and gas oil products. The removed and purified naphthenic acid is a marketable by-product, the sale of which may help to defray the treating costs. For example, with a distillate of 0.55 acid number, the acid removed from a 10,000 bpd stream is about 8,000 pounds per day.

In the Electrofining of distillate streams such as described above, one single two-stage Petreco unit will be assigned to handle a 10,000 bpd stream. After the predetermined volume of caustic wash has been automatically dispersed into the distillate, the mixture enters the first precipitation stage of the Electrofining unit. This treating stage removes the bulk of the spent caustic and the distillate then passes into the second, or water-wash phase. From this second, the distillate emerges as a finished product, ready for market. ##

Meet the Authors

R. A. WILEY has been with Petrolite Corporation since his graduation from Texas A&M College in 1938. An engineer in the company's Petreco division, he is assigned to its Development department and also doubles as safety supervisor for Petreco. Now stationed in Houston, he previously held assignments in the California and Ohio divisions.

Wiley

LOGAN C. WATERMAN has been engaged in various technical and administrative positions with Petrolite Corporation since he was graduated from Rice Institute in 1926. During recent years, he has been concerned with the development and commercialization of distillate-treating processes and equipment. Waterman served with the Air Force during World War II.

Waterman

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The bath is constructed in the form of a solid aluminum block equipped with high temperature sheath chromolox ring type and circular band type heaters. The aluminum block is adequately insulated with 1½" of rockwool to the attractively finished outer jacket. The top of the aluminum block is fitted with a transite asbestos cover. The aluminum block is drilled to accommodate two standard Saybolt viscosity tubes. All wires leading from the heaters run through upright supports to the lower control box which houses two three-heat switches, powerstat (variable heat control) and pilot light. The thermoregulator is of the sensitive bi-metal type operating a heavy duty relay on the intermittent heat circuit. Sensitivity of control at bath temperature of 450°F. is ± 1°F.

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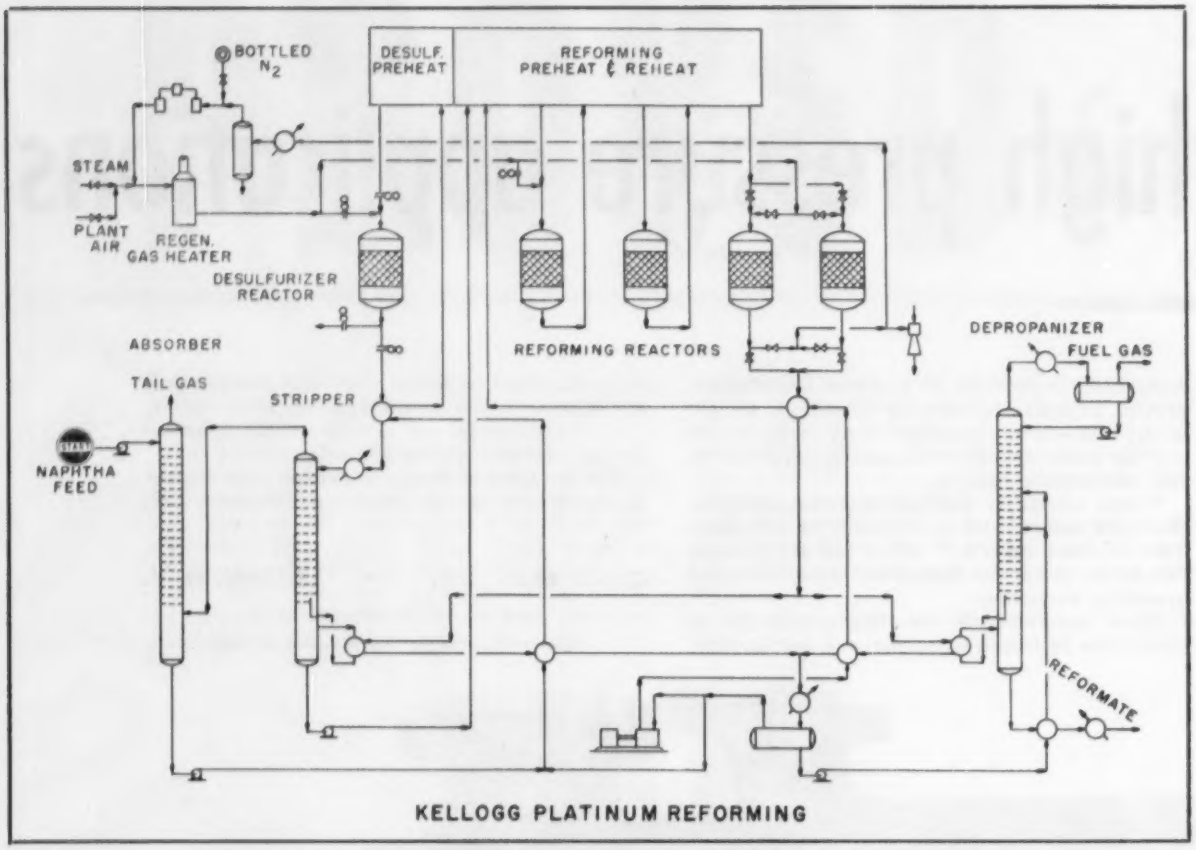

FIGURE 1—Flow diagram for Kellogg-designed catalytic reformer: Removal of poisons makes possible the charging of low grade thermally cracked naphtha.

First Kellogg-Designed Cat Reformer

With Sinclair-Baker catalyst . . . no drop in platinum catalyst activity observed after nine months operation at Pure's Heath refinery.

George W. Stanford,
The M. W. Kellogg Company, New York

THE FIRST commercial installation of the Kellogg designed catalytic reforming unit using the new Sinclair-Baker platinum catalyst has been on stream for over nine months at the Heath refinery of The Pure Oil Company. The Heath unit is a 3000 barrels per stream day unit designed to produce a high yield of either 85 or 90 CFFR (clear) octane of debutanized reformate. The catalyst is characterized by long life due to its capacity for repeated regeneration and for paraffin dehydrocyclization (the conversion of paraffins to aromatics) rather than hydrocracking, increasing the yield of those hydrocarbons which raise octane number while maintaining low volatility.

A feed perparation section is provided to insure long catalyst life and maximum yield of reformate. In this section, the naphtha feed and the hydrogen rich net make gas from the reforming section, are combined and passed over a desulfurization catalyst

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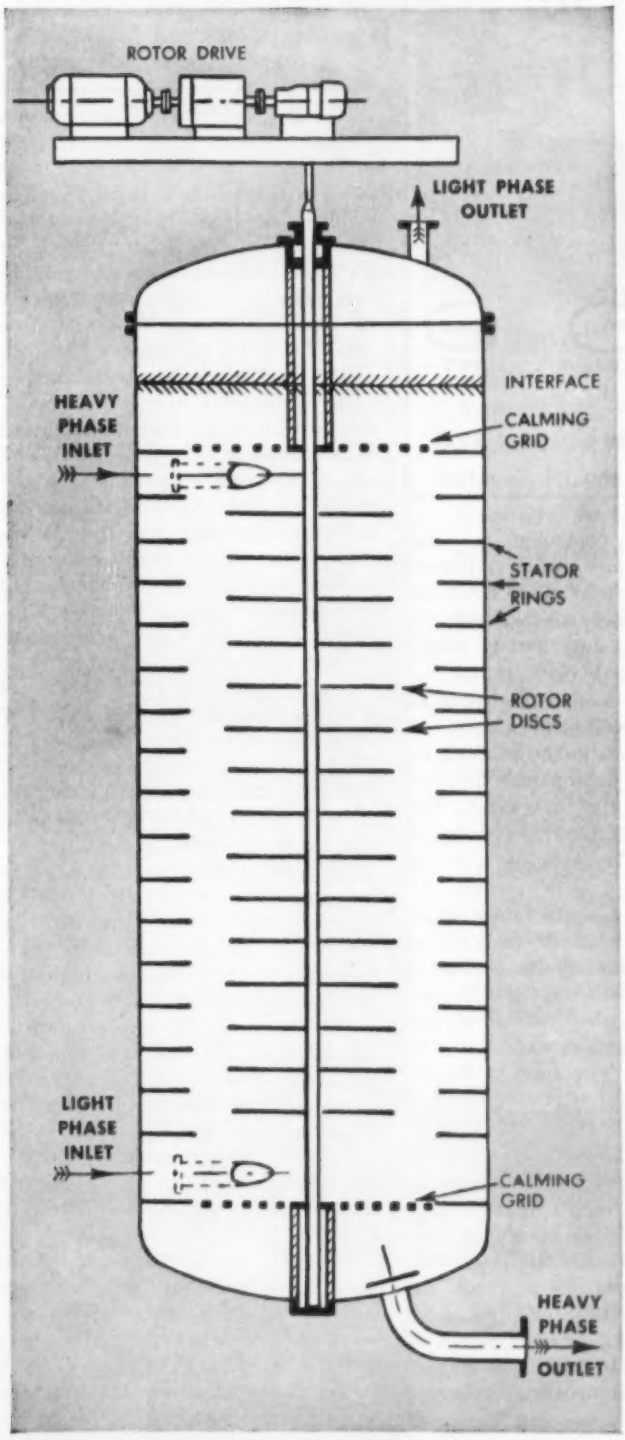
18th Annual

RDC improves extraction efficiency, cuts cost



Rotating Disk Contactor is simple . . . permits flexible operation.

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RDC has been proved conclusively in full-scale commercial services at petroleum refineries and chemical plants. Along every step of its operation RDC cuts expenses, improves products and increases yields, because:

1. It is efficient. It permits the use of less solvent.

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Among the applications of RDC are extraction of lubricating oil, separation of organics, refining of gasoline, purification of plant effluents.

There are many more potential uses for RDC. *Shell invites inquiries about your liquid extraction problems.*

SHELL DEVELOPMENT COMPANY

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TABLE I–TYPICAL YIELDS

	FEED	DEBUTANIZED REFORMATE	DEBUTANIZED REFORMATE
INSPECTIONS			
°API	53.0	45.8	46.7
RVP	0.2	2.3	2.1
ASTM Distillation			
IBP	248	130	138
10%	271	220	236
50%	300	295	297
90%	342	349	352
EP	379	426	419
Octane CFFR			
Clear	39	90.0	84.0
+3cc TEL	—	98.1	94.5
YIELD			
Debutanized Reformate – Vol.%		84.6	87.8
Hydrogen – SCF / Bbl.		960	730

at elevated temperature and pressure.

In this reaction the sulfur is converted to hydrogen sulfide which, after cooling of the effluent, is flashed from the reformer feed with hydrogen rich gas. The desulfurization catalyst also removes metals such as arsenic, copper and lead to trace levels; converts nitrogen compounds to ammonia; and saturates cracked feed stock with hydrogen.

Removal of all poisons for the platinum catalyst in a single feed preparation step besides protecting the catalyst make if possible to charge low grade thermally cracked naphtha direct to the unit.

The reforming section consists of three adiabatic reactors, a combination furnace, a recycle gas compressor, and the associated exchangers for heating the feedstock and cooling of the reactor effluent. The combination furance supplies the heat to preheat the feed and recycle gas to reaction temperature as well as to reheat the effluent from the first and second reactors back to reaction temperature.

Product octane variation is readily accomplished by controlling the reactors inlet temperatures without change of the feed rate. Heat exchange is utilized to minimize the preheat furnace duty and to supply heat for fractionation.

The recovery section consists of an absorber, which insures a high recovery of butanes in the product reformate, and a depropanizer producing a propane free reformate. The reboiler duty for the depropanizer is supplied by the reformer reactor effluent stream.

The infrequent regeneration, is accomplished in blocked operation of both the platinum and desulfurization catalysts. Air with inert gas is used to burn the carbon which is laid down on the platinum catalyst during reaction. Regeneration of the desulfurization catalyst is accomplished by air with steam.

The Heath unit went on stream in September, 1954, and has been in continuous and trouble free operation since. A two-week test run was satisfactorily completed within the first month after startup and all the guarantees for yields and product recovery were met. Demonstration of guaranteed catalyst life will require additional operation over an extended period of time.

The unit has operated at both the 85 and 90 CFFR (clear) octane level in order to meet the gasoline pool requirements of the refinery. Typical yields as well as inspections of the feed and reformates are shown in Table 1. The release gas is unusually rich in hydrogen, a decided economic advantage in over-all refinery operation. Over 45 barrels of feed per pound of catalyst have been charged to the unit without any evidence of deactivation of the platinum catalyst.

Deactivation is readily evident when increased temperature to the reactors is required to obtain a given octane at the same feed rate. A review of the operating data shows that in over nine months of operation no change in temperatures has been required to produce a given octane number product.

The selectivity of the catalyst has been maintained over this period of operation with the unit continuing to produce the same high yield of reformate. There has been no pressure drop build-up across the platinum reactors in the same period.

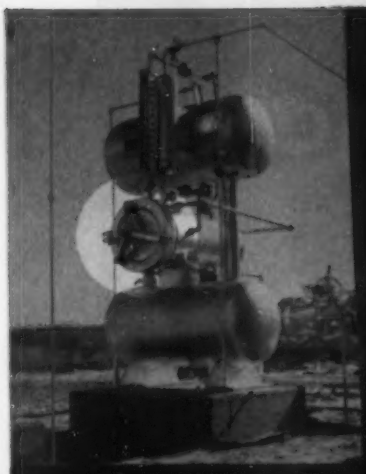
In June of this year the unit was brought down for the first time for a routine mechanical inspection, at which time the desulfurization catalyst was regenerated; the platinum catalyst did not have to be regenerated since there had been no decline in its activity. The unit was inspected for corrosion and exchangers were cleaned. A minimum of corrosion was found and no equipment had to be replaced. The turnaround was easily completed within one week and the unit returned on stream without difficulty.

In the operation following the shutdown the octane of the reformate was brought to the pre-shutdown level without change in the inlet temperatures to the reforming reactors, and pressure drops across the reactors were unchanged. ##

Meet the Author

GEORGE W. STANFORD, senior process engineer with The M. W. Kellogg Company, joined the engineering firm in 1946, following his discharge from the Army. He served as a major during World War II. A chemical engineering graduate from Purdue University where he received his degree in 1941, Stanford is assigned to Kellogg's Refinery Process division. He is a member of AIChE.

PROCESS ISSUE '55
18th Annual



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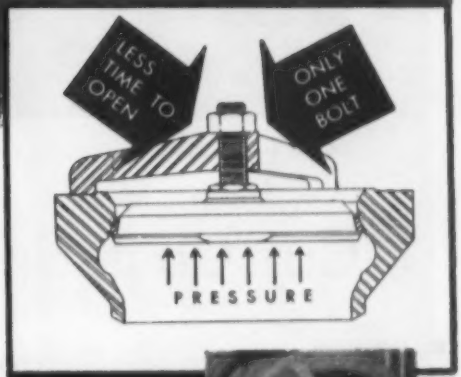

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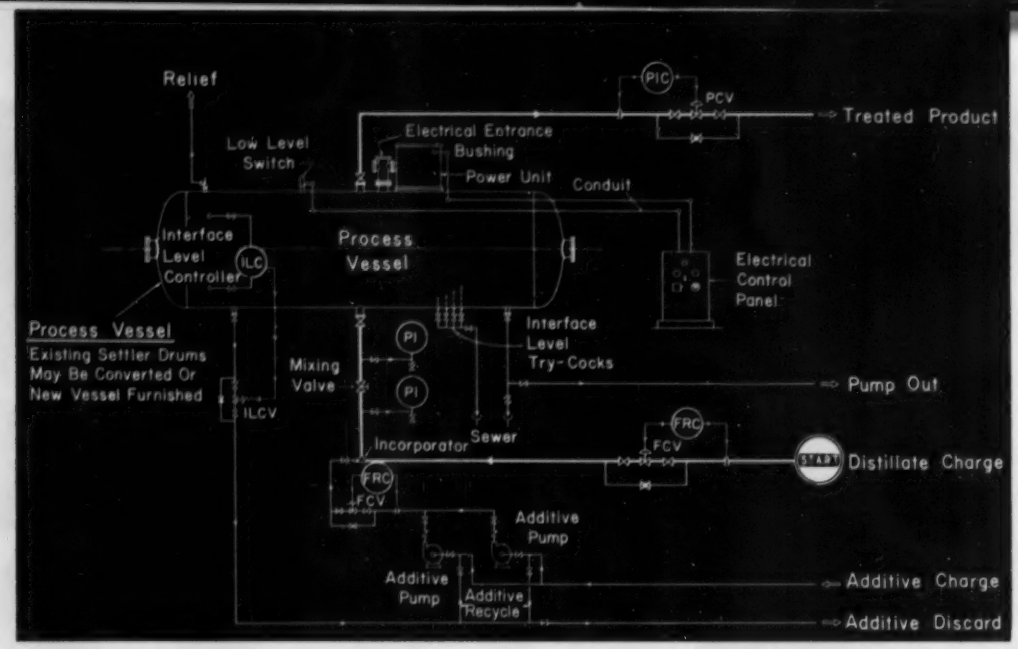

FIGURE 1—Flow diagram for electrical precipitation in distillate treating: More thorough mixing of distillate and treating agent is possible.

Cut Costs in Distillate Treating

Electrical precipitation permits lower chemical consumption and reduces carry-over of addition agent in treated product.

R. J. Phillips
Howe-Baker Corporation
Houston

ELECTRICAL PRECIPITATION to increase the efficiency of distillate treating processes is being used to a rapidly increasing degree. The treating of all distillates, from the naphtha to lube oil boiling ranges, with such agents as caustic, water, and acid can be accomplished more effectively with the aid of electrical precipitation.

The purpose here is to describe the use of electrical precipitation in sufficient detail such that individual refiners can estimate the possible applications to their own problems.

Development of Electrical Precipitation—The principle of electrical precipitation for the separation of oil and water emulsions has been widely used for many years in electrical desalting. The present application, of the same principles, to the resolution of emulsions formed in the castic, water, or acid treating of distillates is simply a refinement of the older process.

Howe-Baker pilot unit studies of the fundamentals of coalescing distillates were initiated many years ago. Since that time, runs using every conceivable type of feed stock have been made on the pilot units. The high point of these studies was the installation, on a temporary basis, of a semi-commercial 1500 barrel-per-day heating oil treater in a large Gulf Coast refinery. It was possible to demonstrate on this commercial-type unit the operability of the process. Subsequent pilot unit studies have pin-pointed the operating variables, including the optimum geometrical configuration for the electrodes, the optimum voltage gradient, the effects of feed stock composition and the concentration and quantity of treating agent, and such operating variables as mixing energy and temperature.

Status of Commercial Units—The first two commercial units are now in operation at a large Gulf Coast refinery. These units electrically precipitate the mixtures formed in the strong caustic and water washing of catalytic heating oil.

Eleven units are now under construction and will go on stream shortly. They are designed for operations involving the electrical precipitation of kerosene, heating oils and lube oils with such additives as caustic, sulfuric acid and water.

Engineering studies are in progress on approximately 60 additional units.

Description of Process—Properly speaking, electrical precipitation should not be described as a new process, but rather as a new way of

TABLE 1
Effect of Better Mixing, Followed by Electrical Precipitation, on Product Quality

FEED STOCK	Treated with	CRITICAL TEST		
		Name of Test	Untreated Feed	Treated Products, Electrically Precipitated
Virgin Heater Oil	1 Percent of 4 Be' NaOH	Neut No.	0.5	0.01
Catalytic Heating Oil	5 Percent of 25 Be' NaOH	Copper No.	18	1.5
Straight Run Gasoline	5 Percent of 20 Be' NaOH	Copper No.	11	1.0
Kerosine	5 Percent Water	Water, K-F	0.22	0.007
Catalytic Heating Oil	5 Percent of 60 Be'/NaOH	Phenols, ppm	700	60

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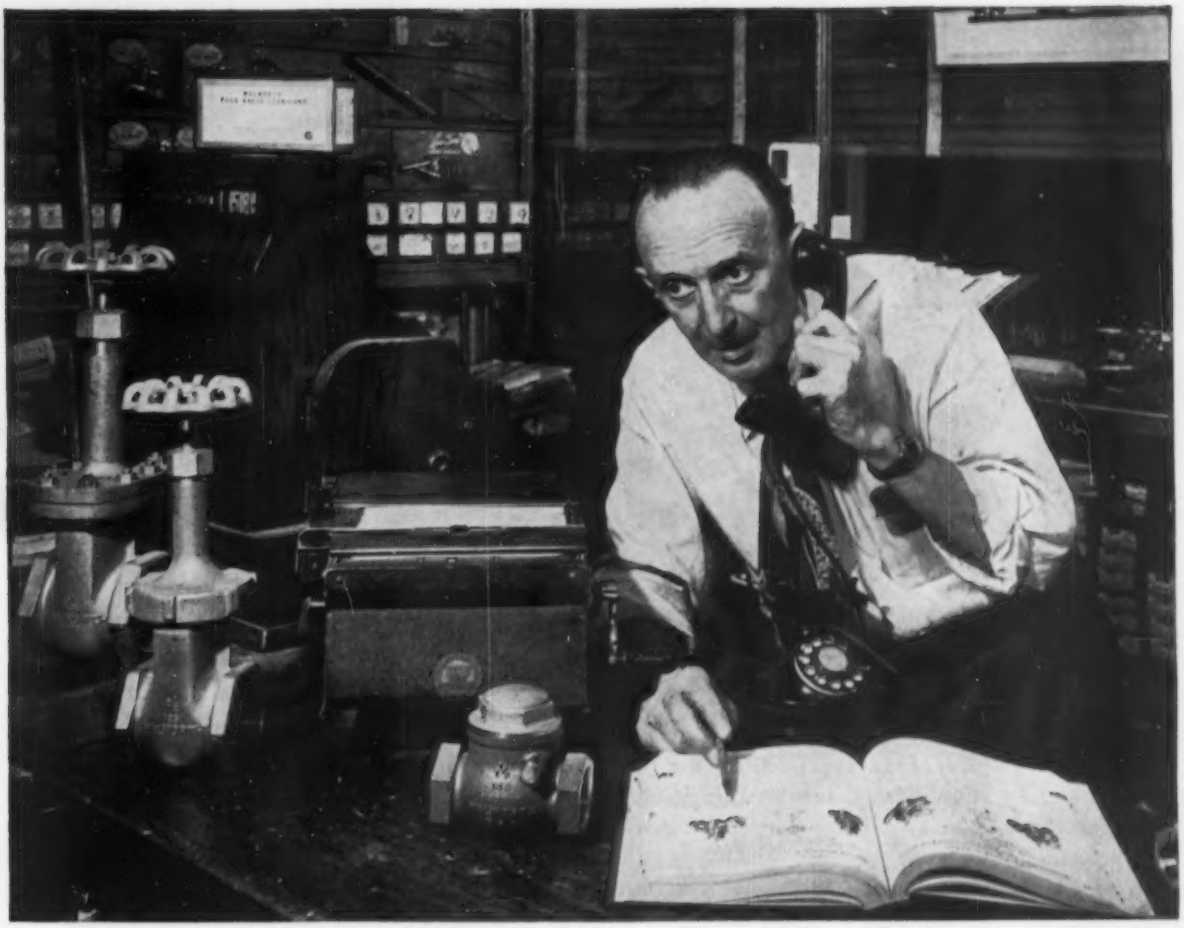

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Each vessel is 5 ft. I.D. by 30 ft. long, has a shell thickness of 2 5/16 in. The material of the main shell meets ASTM specification A-301—a 1 per cent chromium steel with molybdenum.

The internals and bottom head linings are of 13 per cent chrome alloy. These alloy steels were used to meet operating requirements involving temperatures of about 950 F.

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Because of this close attention to design and fabrication details, B&W Pressure Vessels have long enjoyed a reputation for high quality. If your operations require the use of pressure vessels of any type, with working pressures up to 6000 psi, your inquiry will receive careful attention. The Babcock & Wilcox Company, Process Equipment Dept., Barberton, Ohio.

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BOILER DIVISION

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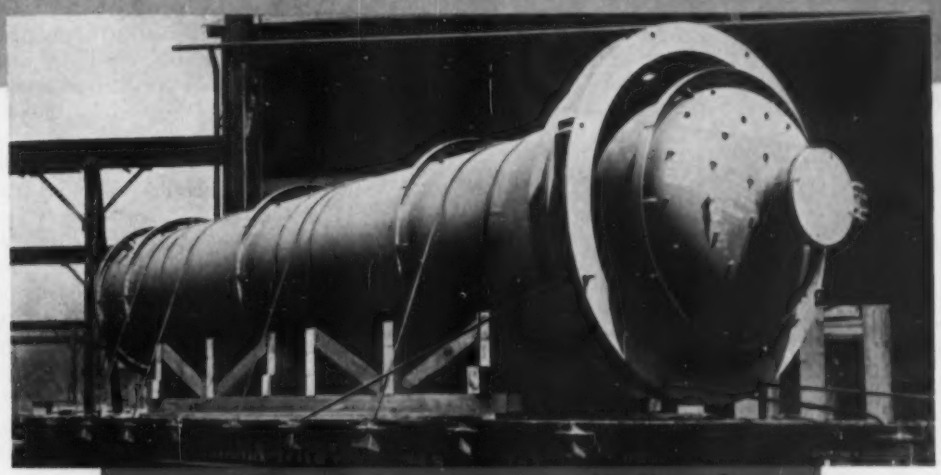
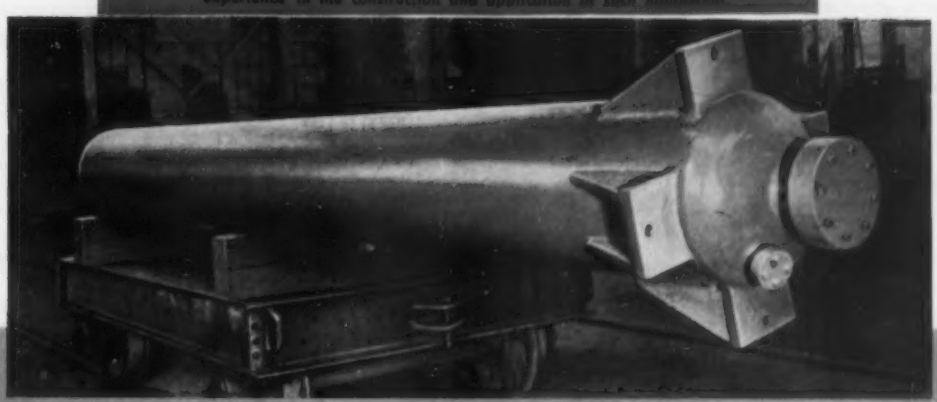


One of the three refinery reactors as it was prepared for shipment. Completion of these special pressure vessels in the comparatively short time required was accomplished by exceptional coordination between the engineering, testing, and fabrication divisions at B&W's Barberton Plant.

B&W Pressure Vessels of all types are designed for various jobs with working pressures to 6000 psi. B&W engineers draw on a wealth of experience in the construction and application of such equipment.



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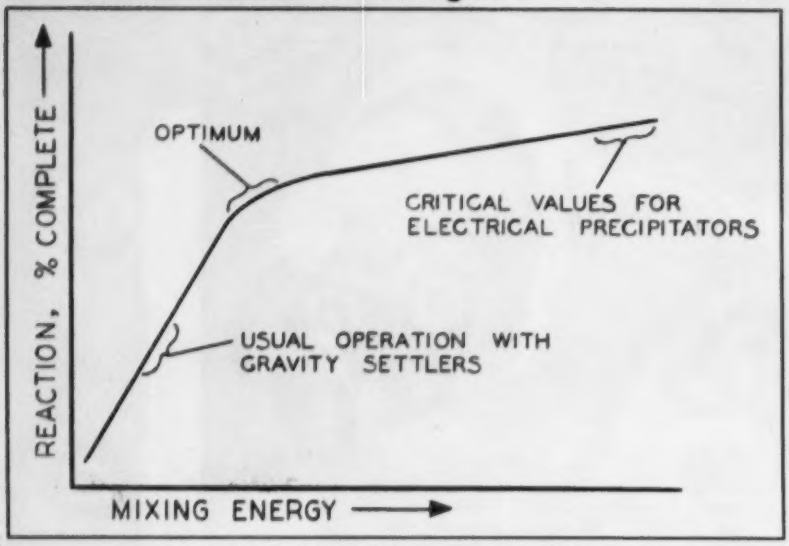


FIGURE 2—What is the optimum mixing energy?

implementing an existing process with a considerable improvement in its performance. Broadly speaking, a high-voltage direct-current electrical field is utilized to resolve emulsions formed in the treating of distillate streams. Since the electrical field will be used, it is possible to mix the distillate and treating agent far more thoroughly.

Hence, for a given product quality, a better and more complete chemical reaction can be achieved with considerably lower consumption of treating agent. In other instances, where the refiner has encountered difficulty in maintaining consistently high product quality, the precipitators insure thorough removal of the treating agent with attendant credits. Such problems as those resulting from water haze can be eliminated.

Figure 1 is a flow diagram of a typical treating system and illustrates the basic process needs of mixing of the feed stock and treating agent, followed by separation in the precipitator.

As can be noted, the process is fully automatic and completely instrumented It is continuous, thereby eliminating many of the ills associated with batch settling. It is customary to have the treater immediately downstream of the preparation unit (crude distillation, catalytic cracking unit fractionator, etc.). The distillate feed stock is mixed with the treating agent in a mixing valve.

It then enters the precipitator vessel, passes through the electrical field, and out to finished storage. The residual treating agent is continuously removed from the bottom of the vessel and can be continuously recirculated until spent. The voltage is fixed during start-up and there is no occasion for operating personnel to change it. All high voltage equipment is fully-enclosed and explosion-proof so there is no danger whatever to operating personnel.

TABLE 2
Carryover of Discontinuous Phase into Treated Product When Using Electrical Precipitators

FEED STOCK	TREATED WITH	CARRYOVER
Catalytic Heater Oil	5 Percent of 25 Be' NaOH	2.6 ppm sodium as NaOH
Catalytic Heater Oil	4 Percent of 50 Be' NaOH	9.7 ppm sodium as NaOH
	10 Percent Water	0.3 ppm sodium as NaOH base-free
Virgin Heater Oil	10 Percent of 10 Be' NaOH	1.2 ppm sodium as NaOH
	10 Percent of Water	0.4 ppm sodium, base-free
Kerosine (Paraffinic)	10 Percent of 15 Be' NaOH	0.6 ppm sodium as NaOH
	10 Percent of Water	0.0 sodium, base-free
Kerosine (Naphthenic)	10 Percent of 15 Be' NaOH	0.4 ppm sodium as NaOH
	10 Percent of Water	0.0 sodium, base-free
Light Naphtha	7 Percent of 15 Be' NaOH	0.3 ppm sodium as NaOH
Gasoline, Straight Run	7 Percent KOH	0.47 ppm KOH
Gasoline, Cat. and Virgin Mixture	10 Percent of 50 Be' NaOH	7.8 ppm sodium as NaOH
Gasoline, Cat. and Virgin Mixture	10 Percent of 30 Be' NaOH	2.9 ppm sodium as NaOH
Lube Oils:		
50 ssu @ 100 F	20 Volume Percent H_2SO_4	0.15 Volume Percent sludge
100 ssu @ 100 F	10 Volume Percent H_2SO_4	0.2 Volume Percent sludge
450 ssu @ 100 F	7 Volume Percent H_2SO_4	0.2 Volume Percent sludge
750 ssu @ 100 F	12 Volume Percent H_2SO_4	0.3 Volume Percent sludge

Process Variables—

1. Mixing Energy. Considerable development activity has been directed toward studies of the optimum levels of mixing energy for different treating processes, the best means of imparting and regulating the energy, and the effect of the energy on the operation of the precipitator. The following general conclusions can be drawn:

a. Present gravity settling equipment does not allow the optimum quantity of mixing energy input since emulsions would result which could not be resolved by gravity settling.

b. Virtually any type of mixing device can be used to impart the required mixing energy in many cases.

c. There is considerable latitude in the minimum amount of energy required to accomplish the desired reaction, and maximum amount that can be tolerated before imposing excessive loads on the electrical precipitator.

Figure 2 schematically illustrates these principles.

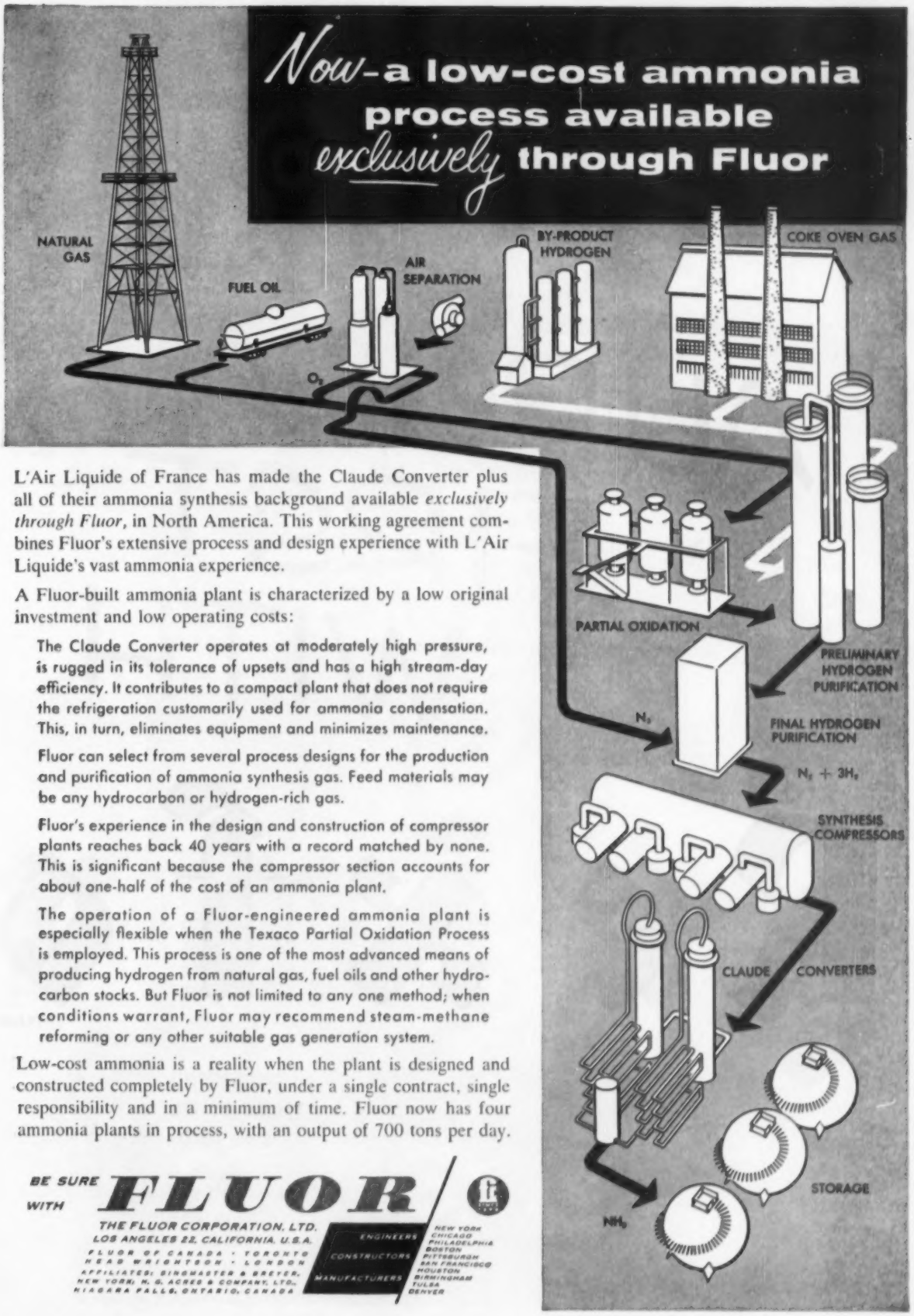
2. Operating Temperature. The operating temperature has little effect on the efficiency of the precipitator except in those cases where the feed stock is extremely viscous, such as lube oils. For all distillates from diesels and heater oils to lighter fractions, the precipitator may be operated at whatever temperature is set by plant operations preceding the treating step. In those cases where it is desirable to reduce the water concentration in the treated product to a minimum, it is always advantageous to operate the treater at the minimum possible temperature to reduce the amount of water held in solution.

In caustic washing operations conducted in cold climates, the lower limit of the temperature may be set by the temperature at which the caustic will solidify. For the very viscous feed stocks (e.g. lube oils above 200 SSU at 100 F.) the optimum operat-

TABLE 3
Treated with 25° Baume Caustic Soda and Electrically Precipitated

TEST	Feed	Product
Copper Number	18	1.5
Mercaptan Number	15.2	1.47
Sodium Content	....	2.8
ASTM Distillation F.:		
IBP	390	
5 percent	464	....
95 percent	605	....
FBP	633	....

Now-a low-cost ammonia process available *exclusively* through Fluor



L'Air Liquide of France has made the Claude Converter plus all of their ammonia synthesis background available *exclusively through Fluor*, in North America. This working agreement combines Fluor's extensive process and design experience with L'Air Liquide's vast ammonia experience.

A Fluor-built ammonia plant is characterized by a low original investment and low operating costs:

The Claude Converter operates at moderately high pressure, is rugged in its tolerance of upsets and has a high stream-day efficiency. It contributes to a compact plant that does not require the refrigeration customarily used for ammonia condensation. This, in turn, eliminates equipment and minimizes maintenance.

Fluor can select from several process designs for the production and purification of ammonia synthesis gas. Feed materials may be any hydrocarbon or hydrogen-rich gas.

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ing temperature will generally fall within the range of 100-150 F.

3. Concentration and Quantity of Treating Agent. In most treating operations dependent on gravity settling, it is usually necessary to "overtreat" from both the quantity and concentration standpoints. The more intimate mixing, followed by more effective separation, made possible by electrical precipitation, usually permits a reduction in chemical consumption of from 30-60 percent.

Since the contacting afforded is much better, the concentration level also can usually be lowered slightly if this is desirable. However, this reduction is small since the optimum concentration is more dependent on the nature of the contaminants to be removed.

Comparison With Gravity Settling—Electrical precipitation has a number of remunerative advantages over gravity settling, many of them obvious, but including:

1. Much lower carryover of the discontinuous phase, whether it be water, caustic or acid. Tolerances are usually considerably lower than those possible to achieve by gravity settling, regardless of the amount of residence time provided in the latter case.
2. Fully automatic, insuring constant product quality without upsets and surges of carryover.
3. Ease of operation, reducing labor and supervision requirements.
4. Reduction in final and intermediate storage tank requirements since the charge can come directly from the distillation unit, through the electrical coalescer, and on to final storage without need for intermediate tankage or time in storage before shipment.
5. Reduced operating costs by eliminating the need for salt drying, clay filtration, etc. The only operating costs for the coalescers are the power requirements, which never exceed 5 KVA under normal operating conditions.
6. Reduced chemical consumption in treating operations. Far more vigorous mixing can be used since the electrical field will resolve any normal emulsion where gravity settling would not. This reduction in chemical consumption will usually amount to about 30-60 percent of the normally required quantities.
7. Reduced pollution, since lower chemical consumption and carry-over to tankage reduces chemicals to effluent.
8. Virtual elimination of maintenance, since the electrical precipitators require only routine annual inspections.
9. Improved sludge quality and pumpability, since the process is vapor tight and air is excluded; oxidation products in sludge are eliminated.

Meet the Author

ROBERT J. PHILLIPS is former editorial director of the PETROLEUM REFINER and now manager of the Treating division of Howe-Baker Corporation. Phillips is a chemical engineering graduate from the University of Texas. Phillips was with Humble Oil & Refining Company at Baytown, Texas, for four years before he joined the REFINER in 1952. With Humble he held successive ranks of junior engineer, assistant engineer and chemical engineer. His professional work has been primarily in distillation, extraction, economics, process design and planning of operations. He also served as lecturer in several company-sponsored schools for new technical employes at the Baytown refinery.

Economic Justification of a Typical Plant Installation—In this typical case, chosen to demonstrate the rapid payout for electrical precipitation, the basis for the economics is as follows:

Feed Stock — 15,000 B/D of Catalytic Heating Oil

Treated With: — 5 percent of 15° Baume' sodium hydroxide, recirculated.

The existing plant has the following sequence:

Caustic Wash—Water Wash—Tankage—Salt Dry—Tankage—Clay Filter—Finished Tankage

The proposed electrified plant will eliminate the need for the water washing, salt drying, and clay filtering steps. The existing 10-foot by 30-foot caustic wash vessel will be used for the caustic wash stage. The treated product will be guaranteed to contain less than 2.0 ppm Na as NaOH, and to be bright (free water less than 0.005 volume percent) with no visible haze.

Equipment Costs: Howe-Baker designs and furnishes the equipment for electrifying the existing vessel. The equipment furnished includes power supply, electrode assemblies, electrical controls, etc., with an approximate installed cost of $50,000.

Economic Credits

1. **Reduced chemical consumption.** Will reduce caustic consumption from present level of 3.5 tons per day to 1.8 tons per day (based on weight of actual caustic), a savings of 1.7 tons per day. With caustic at $70 per ton, this amounts to $119 per day or 0.8 cents per barrel.
2. **Elimination of salt drying operation.** Savings of operating costs of 0.9 cents per barrel, or $135 per day.
3. **Elimination of clay straining operation.** Savings of operating costs of 1.9 cents per barrel, or $285 per day.
4. **Elimination of water washing step.** Savings of operating costs of 0.2 cents per barrel, or $30 per day.
5. **Released Tankage.** Existing intermediate storage tanks are released for other service. They consist of 1—80,000-barrel tank and 2—40,000-barrel tanks, with a total replacement value of $300,000, and a realistically depreciated value of $160,000.
6. **Salvage value of equipment.** The vessels used in the water washing and salt drying operations have an estimated salvage value of $18,000, and the clay straining equipment a salvage value of $20,000.

Summary of Credits—

Item	¢/Bbl.	$/Day
1. Reduced chemical consumption	0.8	120
2. Shutdown salt dryer ..	0.9	135
3. Shutdown clay filter ..	1.9	285
4. Shutdown water wash.	0.2	30
	3.8	570
	= $208,000 per year	

Return on $50,000 Investment = 416%/year

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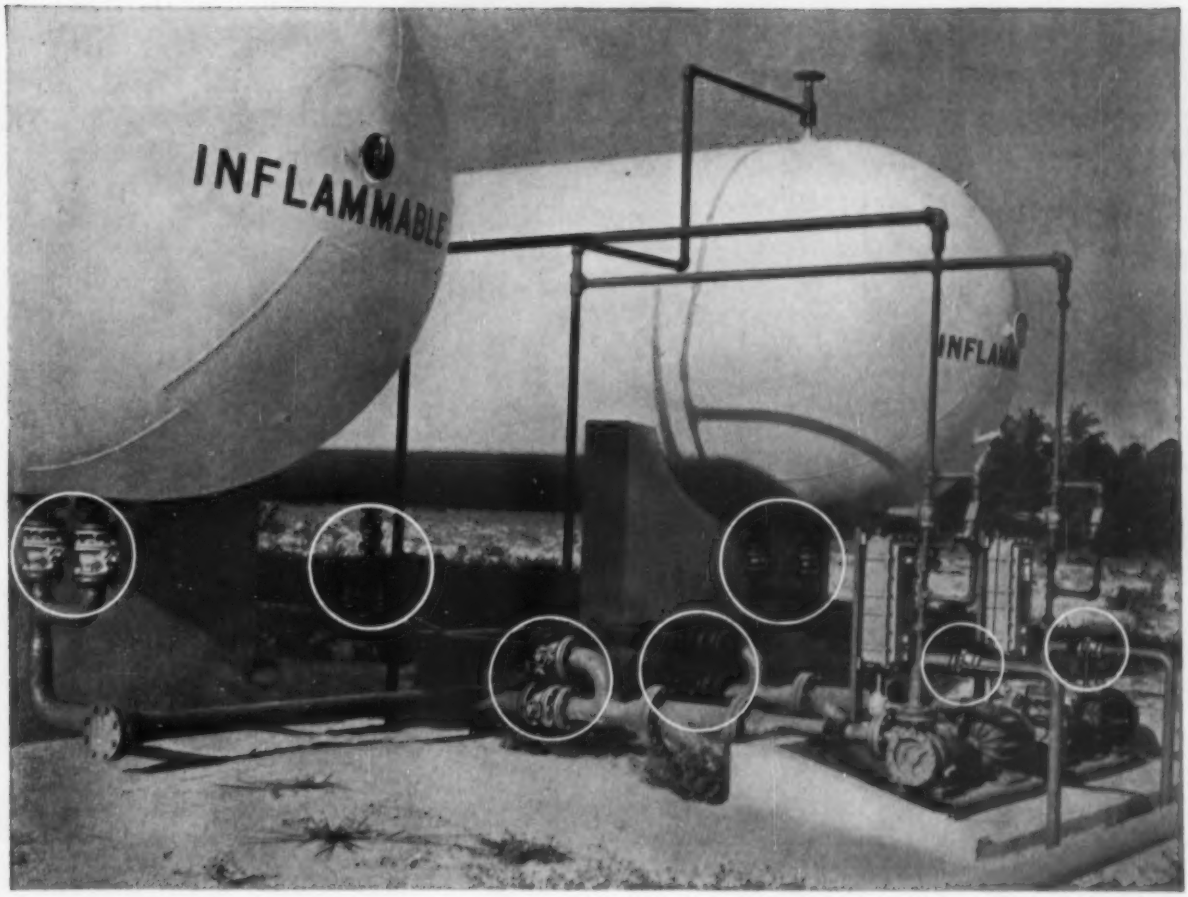

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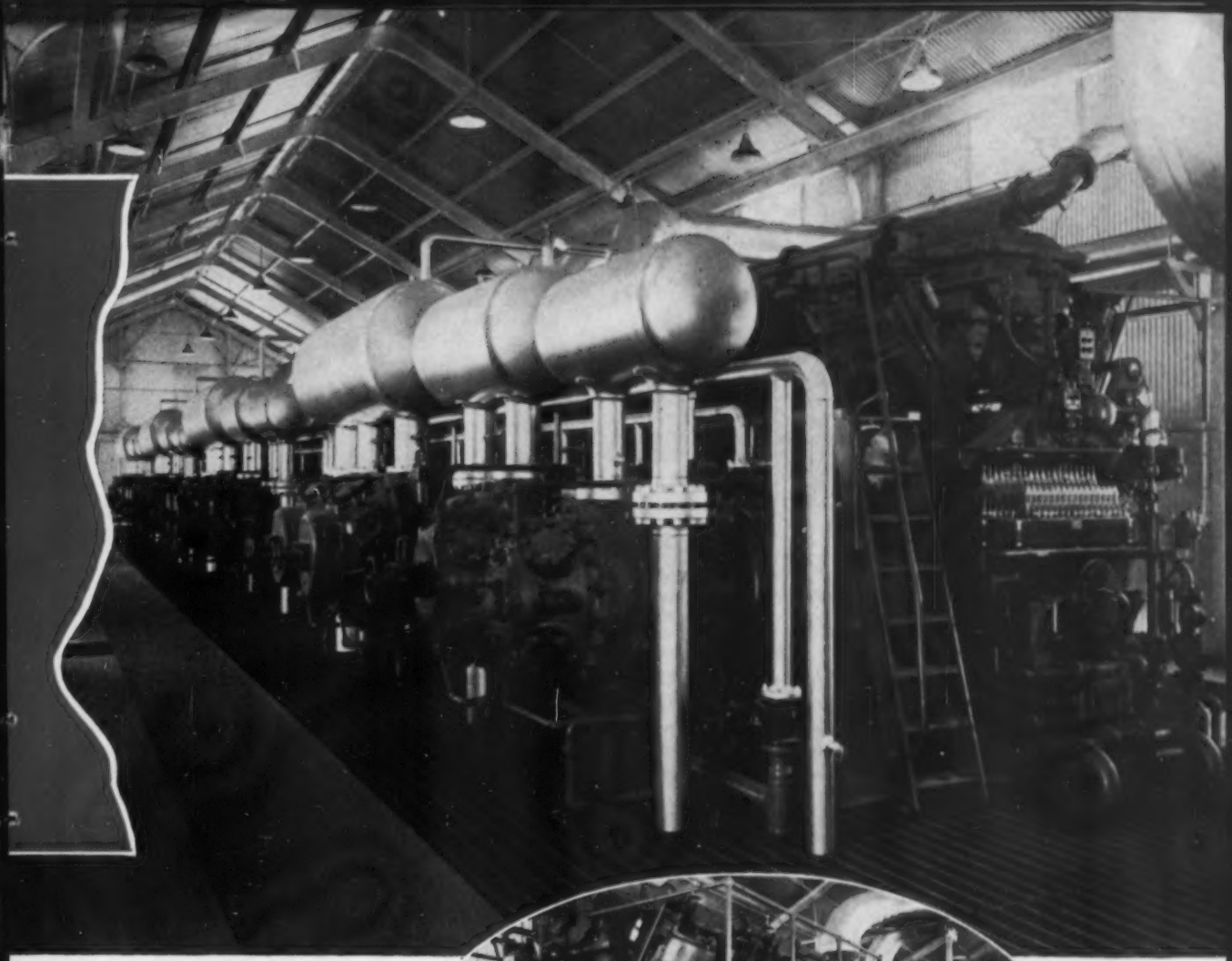
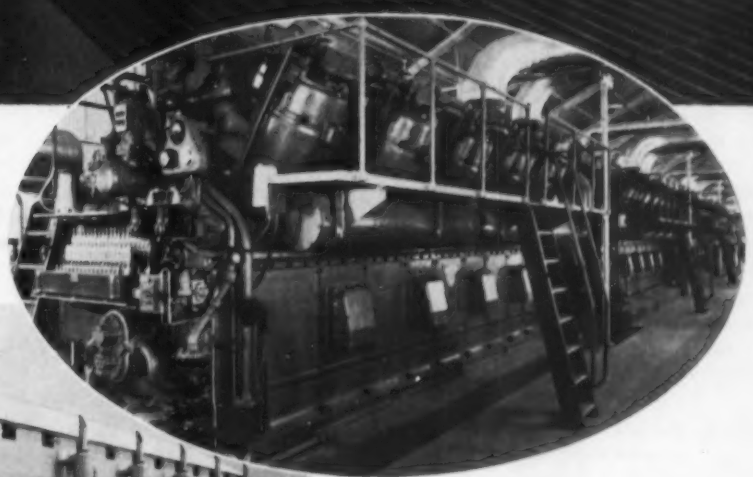


Here are two different views of the Cooper-Bessemer GMVA compressors in Warren Petroleum's Saunders Plant.



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How the First TCP* Unit Operates

***Thermofor Continuous Percolation: At Coryton unit, oil losses average less than 1 percent; clay losses are about 1 percent per cycle.**

A. D. Pukkila and G. L. Payne
Socony Mobil Oil Company, Inc.
Paulsboro, New Jersey

THERMOFOR Continuous Percolation (TCP) is a new finishing process used for improving the color and stability of lubricating oils and waxes. The first commercial installation is in operation at the Vacuum Oil Company, Limited, refinery, Coryton, England.

In the process, the principle of continuous countercurrent flow of granular solids and fluids has been applied to the percolation and clay washing sections of the operation. The remainder of the process consists of a simple continuous clay drier, and a Thermofor clay-burning kiln.

Prior to the development of the TCP process, refiners had a choice of one of two lubricating oil finishing schemes; percolation through static beds of granular adsorbents such as Fuller's earth clay or bauxite, or hot contacting with powdered activated clays.

Generally, the hot contacting process has been favored for new installations because of the lower capital investment required. However, the hot contacting process involves higher clay consumption, greater oil loss, and spent clay disposal problems.

The advantages of fixed bed percolation were greatly enhanced with the introduction, in 1939, of the thermofor clay burning kiln by Socony Mobil Oil Company, Inc.[1,2] Installed in the decolorizing plants of lubricating oil refineries, the thermofor kiln more than doubles the life of percolation clays. This resulted from improved control of temperature of the clay during burning. However, to be competitive with hot contacting, the static bed percolation process required a lowered investment, and further reductions in operating costs. The high cost of such lubricating oil finishing operations provided the incentive for the development of a new moving bed process.

The TCP process was developed in the Research and Development laboratories of the Socony Mobil Oil Company, Inc., in Paulsboro, N. J. The development of the process progressed from laboratory size equipment to the design and operation of a 500 barrel-per-day pilot unit, and finally to the design and operation of a 3000 barrel-per-day commercial unit at Coryton, England. (A similar plant has been installed more recently by the Royal Dutch Shell Company at Pernis, Holland.) Previous publications have described the laboratory and pilot plant work[3] and the design of the Coryton unit.[4] More recently, results of initial operation of the Coryton TCP unit were reported before the Fourth World Petroleum Congress.[5] The present paper reviews the design and performance of the Coryton plant as of this writing.

Process Description—The Coryton TCP unit is designed on the basis of 3000 bpd thruput, using 15/30 mesh grade Fuller's earth clay as the decolorizing medium. Bauxite, or other granular material having decolorizing activity may be used. The production rate of the unit is actually varied from about 1000 to 4200 bpd depending upon the type of stock being finished and the color level desired. A flow diagram of the plan is shown in Figure 1.

In describing the process and the mechanical design of the unit it is convenient to consider the various sections individually. These include the following:

- Percolation Section—consisting of the percolator and its auxiliary equipment for feeding and withdrawing clay and oil.
- Clay Washing and Drying Section—including the naphtha wash tower and the clay drier.
- Regeneration Section—comprising the Thermofor Kiln and the dry clay handling system.
- Naphtha Recovery System.

The process may be described using the flow diagram (Figure 1) as a reference.

1. Percolation Section

The oil to be finished is preheated and introduced into the bottom of the 14.5 foot-diameter percolation tower, through nozzles, which distribute the charge uniformly across the area of the tower. The temperature is adjusted to maintain the vis-

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First TCP Unit . . .

cosity of the oil at about 5 centipoises. The oil flows upwards through the downward moving bed of clay and passes out at the top of the percolator, and then through a blotter press, a steam stripping tower and a heat exchanger to storage.

Two clearly defined phases exist in the percolation tower: a dense oil-clay phase contained in the bottom 17 feet of the tower represents the percolation zone; and above this a 3-foot disengaging section from which clay-free oil overflows.

Regenerated clay from the kiln is fed to the top of the percolator through a metering and distributing device which supplies equal amounts of clay to the seven feed legs entering the percolator. The feed legs are spaced symmetrically with respect to the area of the tower.

Dry clay from each feed leg falls into a de-airing tube partially immersed in the oil phase at the top of the percolator. This tube provides a quiescent zone where the clay particles are wetted by the oil. After wetting, the particles fall through the oil phase and merge with the clay bed.

The spent clay is withdrawn from the bottom of the percolator through a multi-pipe draw-off system spaced

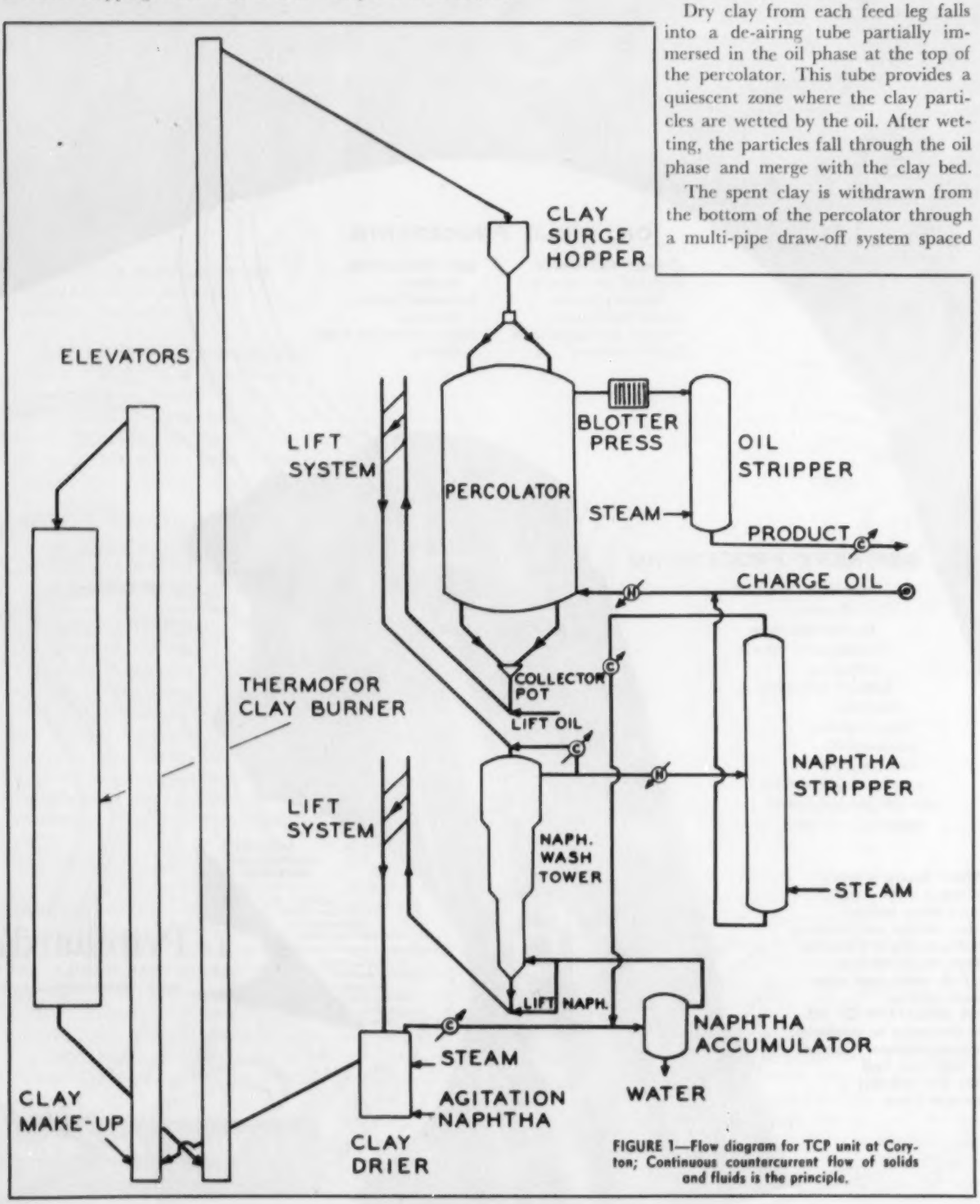

FIGURE 1—Flow diagram for TCP unit at Coryton; Continuous countercurrent flow of solids and fluids is the principle.

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symmetrically with respect to area. The pipes terminate in a collector pot beneath the percolator. A seal leg transfers the spent clay, as a settled bed, from the bottom of the collector pot to the inlet of a lift pipe. The clay slurry flows up the lift pipe to an appropriate crossover connection, which discharges into the wash tower feed leg. Several crossovers are provided for operating flexibility and accurate rate control. The lift is designed to operate on a slurry containing 75 percent concentrated clay-oil slurry and 25 percent free oil. The excess liquid is added at the bottom of the seal leg.

2. Clay Washing and Drying Section

• Wash Tower

The washing step is designed to remove oil from the spent clay slurry, using intermediate boiling range paraffinic naphtha as the solvent. The step involves continuous counter flow of naphtha and clay in a column similar in design to the percolator. The wash tower has three sections of different diameter. These include the top or disengaging zone; the intermediate zone where most of the absorbed oil is removed; and a bottom or clean up zone. The temperature at the top of the tower is maintained below 200 F., which on many stocks requires quenching by use of a cooled recycle stream. Discharge of washed clay from the tower is accomplished with a lift system similar to that described for the percolator.

• Clay Drier

The washed clay is fed continuously into the drier. The naphtha is vaporized by indirect heat exchange with steam heated coils. The clay in the drier is agitated with superheated naphtha vapors. This facilitates heat transfer and also control of the clay drier discharge. Dry clay flows over a weir to a seal leg which discharges into the regeneration system. The naphtha vapors are condensed and re-used as wash tower solvent. The drier at Coryton operates at about 400 F.

3. Regeneration Section

Dry spent clay is transferred by a bucket elevator system to the thermofor kiln. Adsorbed color bodies and oily materials are burned under controlled conditions in the kiln. Specially designed heat transfer coils, containing molten heat transfer salt, are used to control the temperature in the burning zone, thereby avoiding overheating. Regenerated clay is cooled and passed back to the percolator and re-used.

4. Naphtha Recovery System

The effluent from the top of the wash tower is a mixture of about 60 percent oil and 40 percent naphtha. The naphtha is separated in a steam stripping tower, dried and re-used as wash solvent. The naphtha-free oil is combined with the fresh oil feed to the percolator.

Operation of TCP Unit—TCP operations at Coryton have demonstrated that the process has excellent operating flexibility. Yields and thruputs meeting design requirements have been realized on all types of stocks. The transition between charge stocks has been readily accomplished without interrupting the operation.

Total oil losses have averaged less than 1 percent of charge. Clay losses are about 1 percent per cycle of circulation. Following is a discussion of the salient features of these operations.

Charge Stocks

The range of stocks processed to date include light neutral, heavy neutral, and bright stock. The neutral stocks are prepared as vacuum distillates which are treated further by furfural extraction and MEK dewaxing. The bright stock is prepared by subjecting the vacuum residue to propane deasphalting, furfural extraction and MEK dewaxing. These stocks have been processed for production of both motor oils and turbine oils.

Percolation

Processing of such a variety of stocks calls for wide flexibility in adjusting clay to oil ratio. In practice this is achieved by setting the clay circulation rate somewhere in the range of 30 to 60 T/D and regulating the oil rate to obtain the desired product quality.

Typical data on rates and product yields obtained on these stocks are shown in Table 1. In producing motor oils, product rates of 4200 bpd have been obtained on light neutral and 3250 bpd on heavy neutral, with a 30 T/D clay circulation rate. This corresponds to product yields of 140 and 110 barrels per ton, respectively. With bright stock, a product rate of 2100 bpd was obtained at a clay circulation of 54 T/D. When running light and heavy neutrals for turbine oils, oil rates were 1600 and 1900 bpd, and clay rates 56 and 59 T/D, respectively. Bright stock turbine oil was produced at a rate of 550 bpd.

Washing and Regeneration

Virtually complete oil recovery from the spent clay has been achieved at Coryton with wash ratios in the range of 0.4 to 0.7 volumes of naphtha per volume of clay. The effectiveness of this washing operation is reflected in the very low oil losses experienced to date.

The operation of the clay drier has been relatively simple to maintain,

Meet the Authors

Payne

GRADY L. PAYNE is a chemical engineer in the Research and Development laboratories of Socony Mobil Oil Company, Inc., at Paulsboro, N. J. He has a background of more than 15 years research and process development work on lubricating oils, including pilot-plant design and construction. Payne attended Piedmont College and Georgia Institute of Technology, receiving his degree in 1934.

Pukkila

ARNOLD O. PUKKILA is a research associate in the Socony Mobil Oil Company's Research and Development laboratories at Paulsboro, N. J., where he is concerned with development activities in lube-oil refining and thermal processing. Pukkila joined the company in 1944, following his graduation from the University of Minnesota where he received a degree in chemical engineering.

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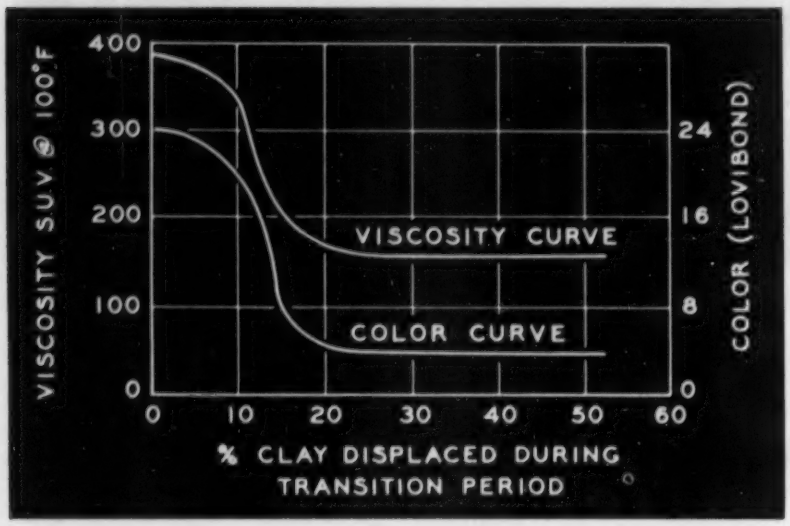

FIGURE 2—Feed stock transition period: From heavy to light neutral in the time required to replace 20 percent of the adsorbent in the percolator.

even at 55 to 60 tons per day clay circulation rates. The dried spent clay contains 1 percent extractable hydrocarbons and 3 percent residual carbon. This material is removed in the thermofor kiln.

Decolorizing Efficiency

In Table 2, data are presented on the decolorizing efficiency obtained at Coryton on two typical Middle East stocks. The efficiency is expressed on a relative basis, using laboratory static percolation on the same stocks and with the same clay, as a reference. The Coryton TCP plant yields exceed those with laboratory static percolation by 35 to 45 percent. Further experience over a number of years in several U. S. refineries using the same grade of clay indicates that commercial static percolation plants show lower efficiencies than laboratory static percolations. Therefore, the improvement over commercial static plant performance is even more marked.

Clay loses decolorizing activity at a much slower rate in the TCP process than in the static percolation process. By eliminating contact of the clay with water and steam the activity is maintained for longer periods. This is demonstrated by commercial operating data shown in Table 3, which indicates that after 40 cycles the Coryton TCP clay decolorizing activity had dropped only to 80 percent as compared to 60 percent after 22 cycles for normal commercial static plant operation.

Stock Transition

As already noted, the Coryton TCP unit has proven to be very flexible with respect to changeover from one charge stock to another. Slop cuts are minimized or eliminated by proper scheduling of charge stocks. As shown in Figure 2, the transition period for changing from heavy neutral to light neutral involved only the time required to replace 20 percent of the adsorbent in the percolator. When transition production is considered in terms of product oil thruput, equilibrium is reached after one complete displacement of oil volume in the percolator.

Operating experience has shown that the finished oils produced are of satisfactory quality in comparison with commercial contact or static percolation production. Some stocks, however, are sensitive to odor development. At Coryton this has been corrected by installation of a steam stripping tower after the percolator.

Economic comparisons of the TCP process with hot contacting and static bed processes have previously indicated that the lower operating costs of the TCP process are largely the result of lower clay and oil losses. These economic advantages have been substantiated by operation at Coryton.

TABLE 1
Commercial Operating Data for Typical Kuwait-Iraq Oils

STOCK	LIGHT NEUTRAL		HEAVY NEUTRAL		BRIGHT STOCK	
PRODUCT TYPE	Motor	Turbine	Motor	Turbine	Motor	Turbine
Product Rate, B/SD	4200	1600	3250	1900	2100	550
Product Rate, B/SD/Sq. Ft.	25.5	9.7	19.4	11.5	18.2*	15.5†
Clay Rate, Tons/SD	30	56	30	59	54	38
Operating Temp., F.	250	210	295	310	356	360
Operating Viscosity, Cp.	3.8	4.9	2.8	3.2	4.5	4.5
Charge Color, ASTM	3—	2½—	5—	4—	6—	6—
Product Color, ASTM	2½—	1—	4½—	2½—	5—	3—
Charge Viscosity:						
Saybolt Sec. @ 100 F.	145/155	145/155	350/400	350/400		
Saybolt Sec. @ 210 F.					150/160	150/160
Product Yield, B/Ton	140	28.6	110	32.2	39	14.5

* Superficial rate increased with 900 B/D of product recycle.
† Superficial rate increased with 2000 B/D of product recycle.

TABLE 2
Comparison of TCP and Static Percolation Yields
(Kuwait-Iraq Stocks)

STOCK	Light Neutral	Bright Stock
TCP Yield, Bbl./Ton	140	31
Laboratory Static Yield, Bbl./Ton	102	21.5
Ratio $\frac{\text{TCP Yield}}{\text{Lab. Static Yield}}$	1.37	1.44
Ratio $\frac{\text{Lab. Static Yield}}{\text{Plant Static Yield}}$	1.43	1.81

TABLE 3
Comparison of Adsorbent Life for TCP and Plant Static Processes

Adsorbent Condition	New	5 Cycles	19 Cycles	22 Cycles	40 Cycles
TCP Activity, Percent	100	98	90	84	80
Plant Static Activity, Percent	100	90	83	60	

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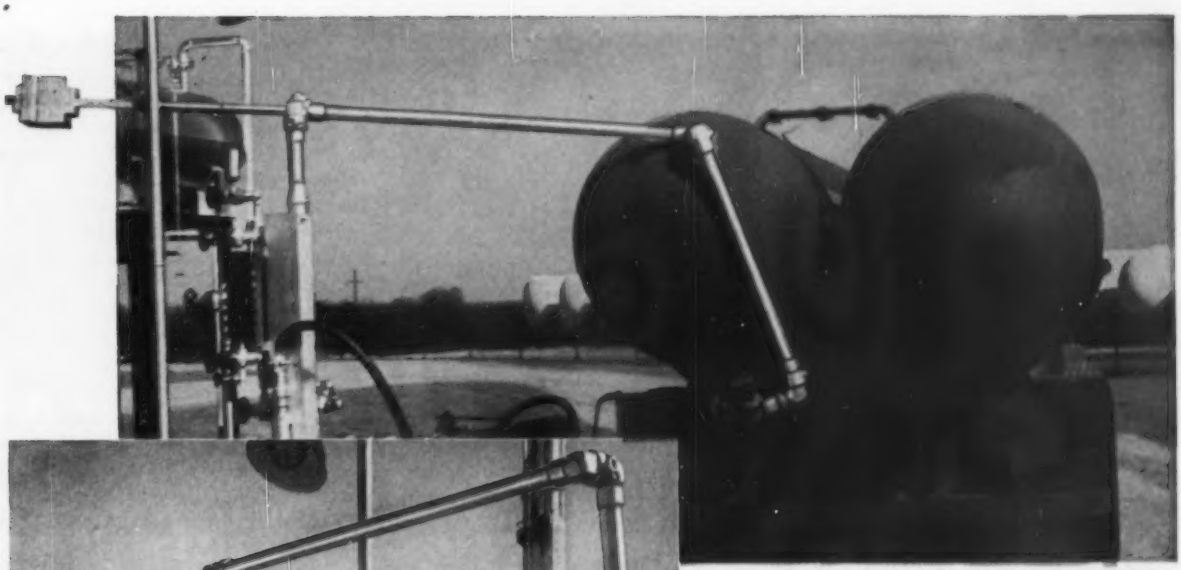

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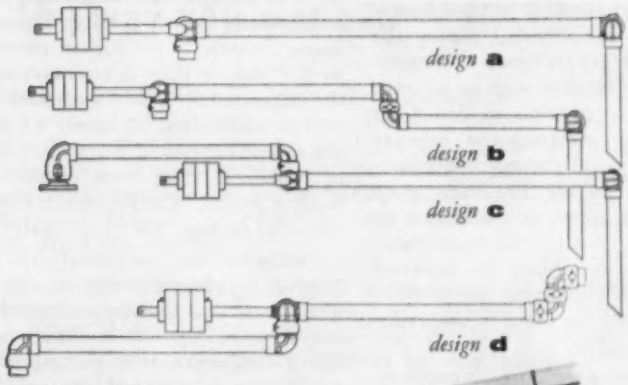

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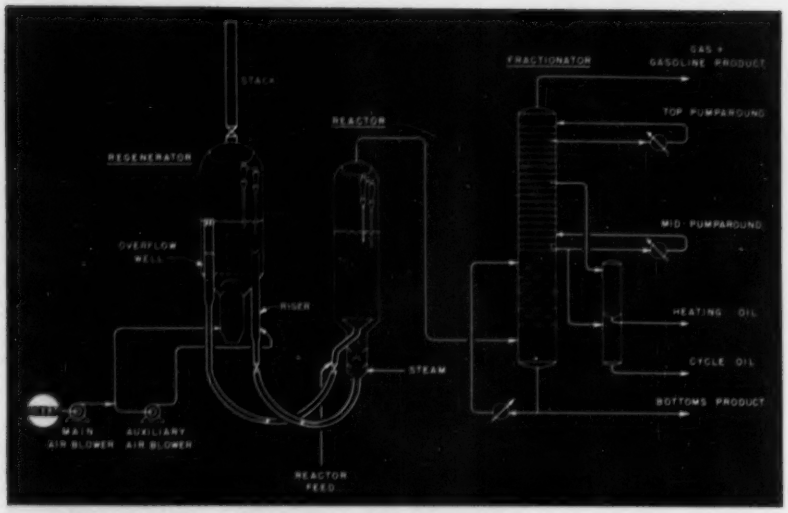

Flow diagram for a typical fluid catalytic cracker: Start-up technique is basically the same for all types.

How To Start Up a Fluid Cat Cracker

Every process man should know at least these fundamentals about starting up a unit of this type.

Walter Ullrich,
The Lummus Company,
New York

FLUID CATALYTIC cracking units have certain basic elements which are common to all presently used designs. The reactor provides a fluidized bed of catalyst of such volume and supplied with regenerated catalyst at such rate and such temperature that the requirements for charging capacity and conversion of heavier hydrocarbon stocks to gasoline are satisfied.

The technique of starting-up the different types of units is basically the same.

1. Testing the Catalytic Section for Tightness—It is good practice to test the regenerator and the reactor with air and the fractionator with steam after a turnaround in order to insure a tight system.

An accepted procedure is to isolate the regenerator and the reactor from the fractionator by installing a blind in the vapor line between the reactor and the fractionator. The regenerator and the reactor are then tested with air using the air blower. During the testing period all joints on these vessels which were disconnected during the shutdown period are taped with masking tape and brushed with an aqueous soap solution in order to detect air leakage. The accepted test pressure may vary from 5 pounds per square inch gauge to 20 psig. The fractionator is tested with steam at a similar pressure to that used for the regenerator and the reactor. When the tightness test has been completed the pressure is released and the blind in the vapor line is removed.

An alternate procedure for conducting the tightness test is to test the regenerator, the reactor and the fractionator as a unit without isolating them. In this procedure steam is introduced into the fractionator at such a rate that steam and air is vented from a vent line installed in the reactor vapor line as the pressure on the system is gradually built up to test conditions by the air blower.

2. Heating Up the Catalytic Section—The regenerator and the reactor are heated up to 600 F. to 800 F. at essentially atmospheric pressure with hot air from the air line heater before adding catalyst to the unit. The heated air is vented through the regenerator stack and through a vent line installed in the reactor vapor line. The fractionator is maintained at a slightly higher pressure than the reactor by means of steam in order to prevent air from entering the fractionator.

The reactor is heated with hot air to minimize the condensation of steam in the next step of the procedure. It may not be necessary to heat the reactor with air if superheated steam is available.

3. Loading the Catalytic Section with Catalyst—When the regenerator and the reactor have been heated to the desired temperature the slide valves in the catalyst transfer lines between the regenerator and the reactor are closed, stripping steam is cut into the reactor and the desired quantity of aeration air or steam is cut into the standpipes and transfer lines. At this time the vent valve in the reactor vapor line may be closed after the reactor has been purged free of air.

The fractionator steam may be cut out and refinery or natural gas may be introduced into the fractionator or overhead accumulator. The relief valve to the flare line on the overhead accumulator system is set to maintain approximately 2 psi higher pressure in the reactor than is maintained in the regenerator. The regenerator air rate is maintained at about 0.8 feet per second superficial velocity in order to reduce catalyst losses during the loading period. The regenerator pressure may be kept low (2 to 5 psig).

Catalyst is now transferred from the catalyst bin into the regenerator at such a rate that the temperature does not drop below 400 F. When sufficient catalyst has been transferred to the regenerator to seal the primary cyclone dip legs and to cover the torch oil nozzle, catalyst addition is reduced to a minimum or discontinued. The regenerator temperature is now raised to 800 F. by means of the air line heater and torch oil is introduced into the regenerator.

Catalyst is again added at a high rate until a maximum safe catalyst level is established in the regenerator

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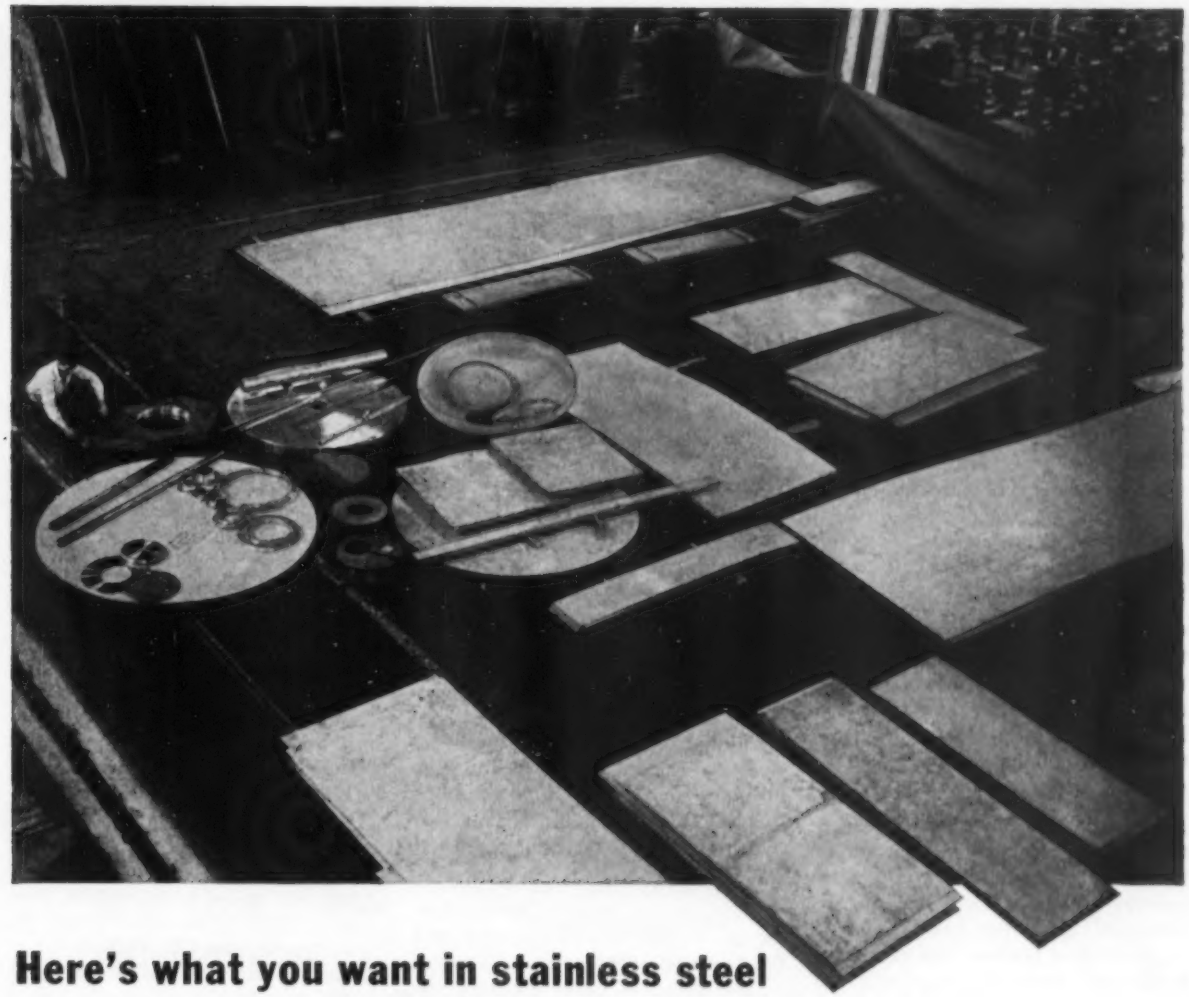

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at which time catalyst addition is again reduced to a minimum. At this point the use of the air line heater may be discontinued and the entire heating load may be transferred to the torch oil. The quantity of catalyst in the regenerator should be sufficient to establish a minimum operating level in both the regenerator and reactor when catalyst circulation is established between the two vessels.

During the catalyst loading period, the back pressure on the air blower increases as the catalyst level rises in the regenerator.

Care must be taken that the air blower does not reach its surge point. If the air blower is permitted to surge, a large quantity of the catalyst inventory in the regenerator may be blown out of the stack and/or hot catalyst may be sucked back into the blower.

4. Introducing Charging Stock to the Fractionator—During the period that a catalyst inventory is being built up in the regenerator, the reactor feed is lined up to the bottom of the fractionator and oil circulation to the bottom of the tower is started.

5. Establishing Catalyst Circulation—When a maximum safe catalyst level has been established in the regenerator, the slide valve in the regenerated catalyst line is slowly opened to the desired position and catalyst is transferred from the regenerator to the reactor. Some of the fine catalyst is now carried out of the top of the reactor to the fractionator and so the oil in the bottom of the fractionator is switched from circulation to storage to prevent catalyst build up in the bottom of the tower.

After an operating level of catalyst has been established in the desired position, catalyst is transferred from the reactor back again to the regenerator. Catalyst circulation has now been established and the reactor is raised to the desired temperature with the heated catalyst from regenerator.

6. Introducing Charging Stock to the Reactor—The slurry oil from the bottom of the fractionator is introduced to the reactor when it reaches a temperature of about 875 F. Carbon now forms on the catalyst. As the carbon on the spent catalyst increases, the temperature in the regenerator rises, which in turn increases the reactor temperature. More feed stock is added to reactor as temperature rises.

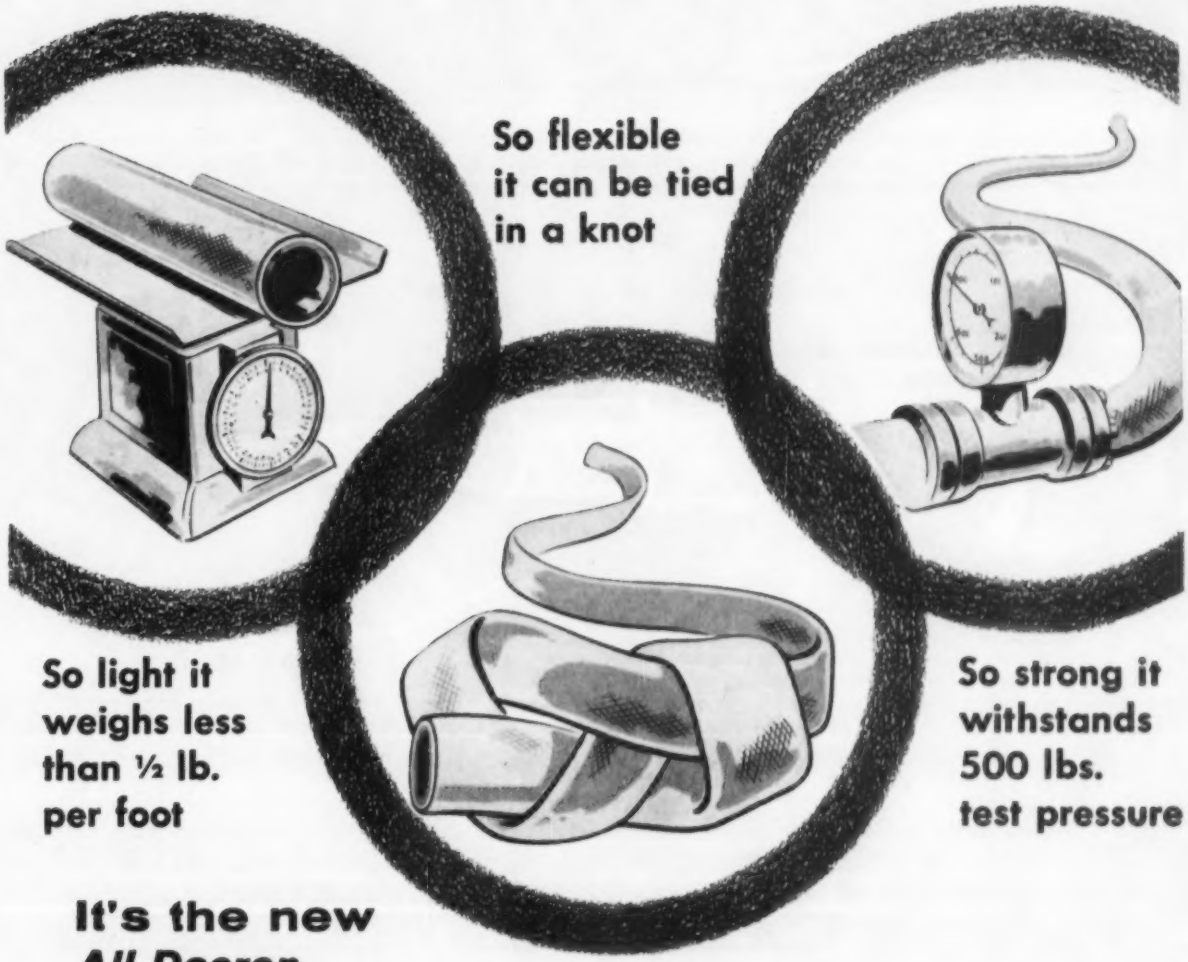
About the Author

WALTER ULLRICH, with The Lummus Company as manager of its Operating division, also has served as assistant director of Gulf Oil Corporation's experimental laboratory and was research director for The Texas Company in its Thermal Cracking division. In addition to a broad background in the refining industry, which includes a period as a consultant in petroleum technology, Dr. Ullrich taught chemical engineering at both the University of Texas and Massachusetts Institute of Technology.

The torch oil addition is decreased until all of the torch oil has been cut out of the regenerator. Catalyst levels in regenerator and reactor, catalyst circulation, reactor temperature, feed rate and air rate are now adjusted to normal operating conditions and the unit is brought into heat balance by adjusting the reactor temperature.

Don't forget these points—Some of the pertinent points to watch during the starting up and operation of a fluid catalyst unit are:

1. For a multi-cyclone recovery system, use a low air rate in the regenerator until the primary cyclone dip legs are sealed in order to reduce catalyst loss during the starting up period. It is assumed that the secondary cyclone dip legs in the regenerator and reactor are equipped with flapper valves or seal pots.
2. Operate the air blower in a safe range sufficiently removed from its surge point during start up by venting a portion of the air to the atmosphere and during operation by controlling the blower speed. If the blower is motor driven, it may be necessary to vent any excess air to the atmosphere during normal operation and/or control the blower output by controlling the suction pressure of the blower.
3. Build an adequate catalyst inventory in the reactor in order that the dip legs of the primary reactor cyclones may be sealed before starting catalyst circulation in order to reduce the quantity of catalyst carryover into the fractionator.
4. Introduce the slurry oil to the reactor as quickly as possible to reduce catalyst loss during start-up.
5. Keep a record of catalyst size distribution. Improper catalyst size distribution affects catalyst fluidization. Poor fluidization characteristics result in poor catalyst circulation, surging catalyst levels in the regenerator and the reactor, poor cyclone performance, after burning, and high catalyst losses. Break up excessive coarse catalyst particles by means of an attrition nozzle or remove it with an elutriator.
6. Watch regenerator temperature and excess air during the starting up period and during operation. During the starting up period when the excess oxygen is high, the regenerator temperature should be maintained below 1050 F. in order to avoid afterburning. When higher regenerator temperatures are necessary for process reasons, the excess oxygen in the regenerator should be reduced to 0.5 to 1.0 percent in order to prevent afterburning.
7. Keep a record of the characteristics of the charging stock to the unit. A change of charging stock usually throws a unit out of heat balance and a new reactor temperature must be found to get the unit back into heat balance.
8. Keep a unit out of a carbon build up. A unit will go into a carbon build up when more carbon is laid down on the catalyst than is required to keep the unit in heat balance. The quantity of excess air will be zero as a unit will not go into a carbon build up unless there is a deficiency of oxygen. The following steps may be taken to take a unit out of a carbon build-up.
   - Reduce the feed preheat
   - Cut the slurry oil to storage
   - Reduce the reactor catalyst inventory
   - Reduce the reactor temperature
   - Take out the excess regenerator heat using the dilute phase sprays
   - Increase the quantity of air to the regenerator when possible avoiding excessive regenerator temperature
   - Watch out for afterburning and be prepared to combat it. A touch of afterburning is usually experienced when a unit comes out of a carbon build up. # #



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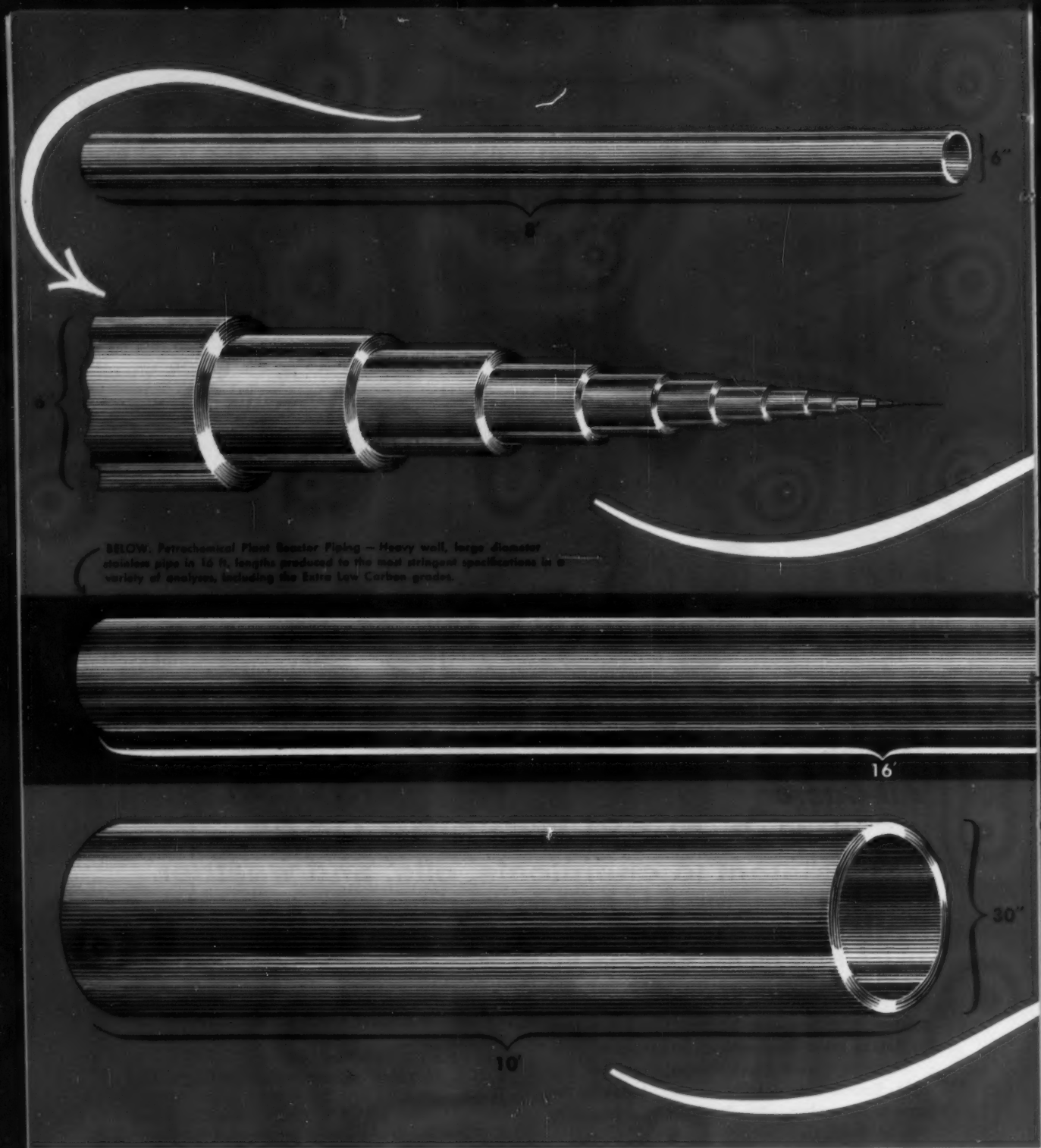

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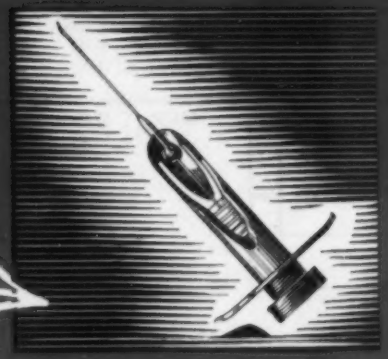

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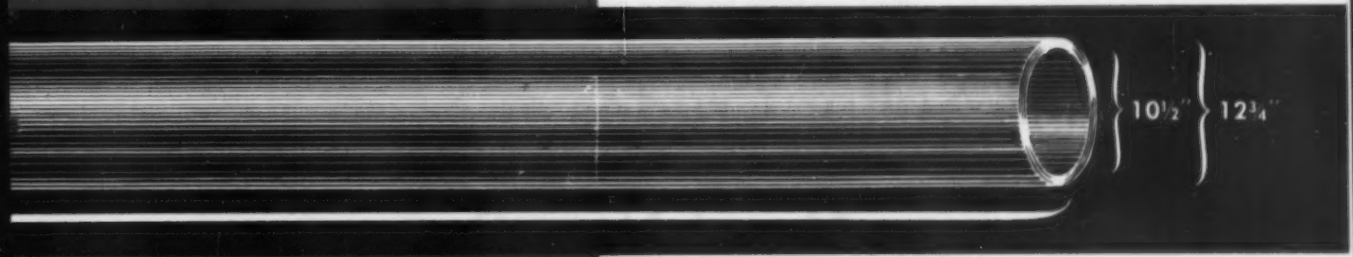

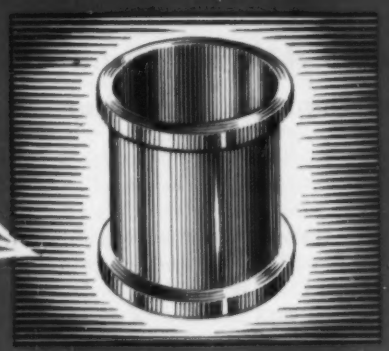

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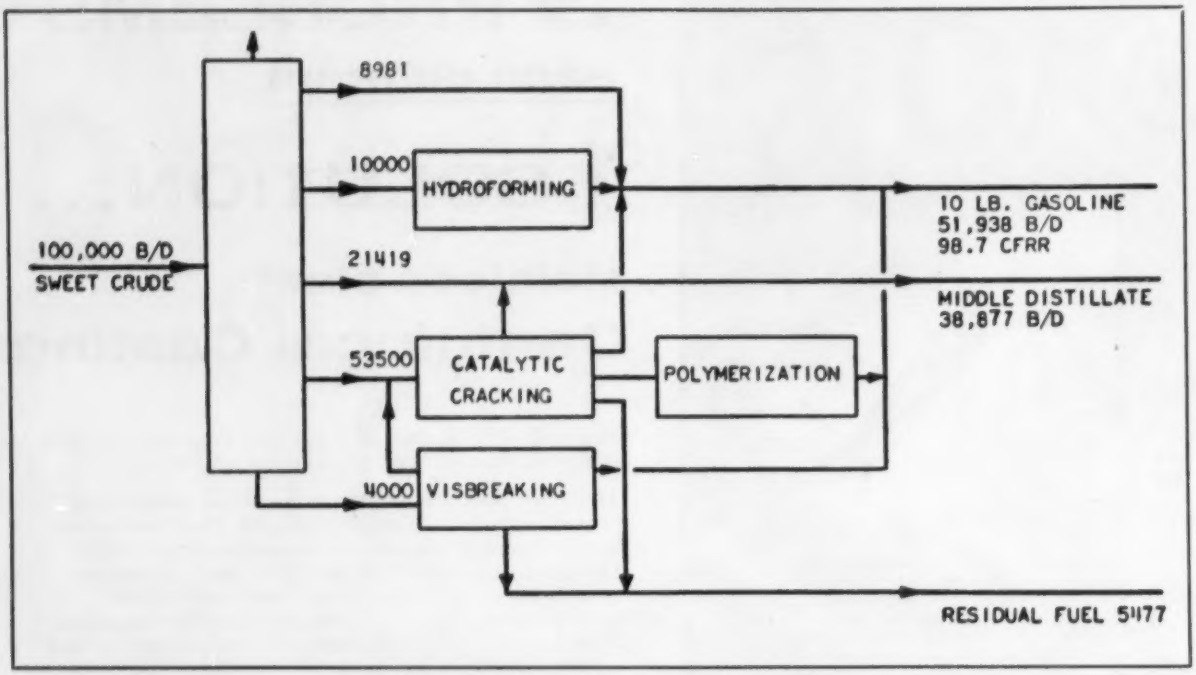

FIGURE 1—Simplified flow plan of sweet-crude-oil refinery.

High Sulfur Crudes Need New Processes

In this hypothetical refinery, the Fluid Coking and Hydrofining processes join hands to permit economical running of high-sulfur crude in a low-sulfur refinery.

W. H. Winslow,

Esso Standard Oil Company, Baton Rouge

John Weikart,

Esso Research and Engineering Company, Linden, N. J.

IN VIEW OF the new crude-oil discoveries of the heavy high-sulfur type, many refineries which are now running with an entirely sweet-crude-oil slate will be faced with the problem of partly switching to a heavy high-sulfur crude oil. This switch will create extensive problems both from the standpoint of product quality and product distribution. To illustrate these problems and the methods for alleviating them, a hypothetical Gulf Coast refinery has been set up. A refinery which has been operating on 100,000 barrels per day of low-sulfur crude oil finds that it must replace 25,000 barrels per day of this better quality crude oil with one of substantially poorer characteristics. The new crude oil is lower in gravity (26 vs. 37° API) and higher in sulfur (2.1 vs. 0.4 percent).

The inclusion of this crude oil in the refinery run creates three problems. First, the yield of heavy fuel is tripled, thus seriously degrading the value of the refinery product yields. Second, the products from the mixed crude oil require more severe treating, largely because of higher sulfur, in order to produce products approximating the quality of those from the low-sulfur crude oil. This treating must be done to lower the sulfur content and to improve the stability and combustion characteristics of the distillate fuels. Third, the high sulfur content of the heavy crude oil will

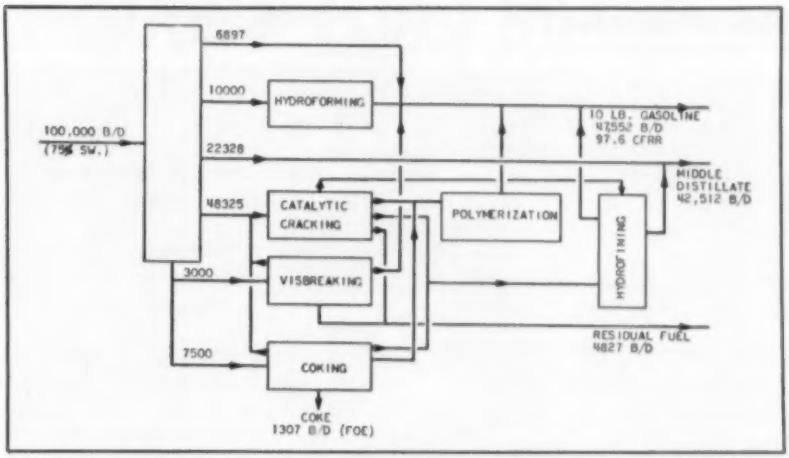

FIGURE 2—Simplified flow plan with coking and product hydrofining.

cause greater corrosion in the refinery equipment, inasmuch as this refinery —like many which run on light low-sulfur crude oils—does not have non-corrosive alloys. The fluid coking and Hydrofining processes join hands to permit the economical running of the high-sulfur crude oil in this low-sulfur refinery.

The hypothetical 100,000-barrel-per-day refinery was assumed to be running to make prime fuel products, viz., gasoline, kerosine, heating oil and diesel oil, and a small quantity of heavy, residual fuel oil. The processing equipment includes three two-stage pipe stills, a fluid hydroformer, a fluid catalytic cracking unit, a small thermal cracking unit, and the necessary light-ends and treating equipment. The capacities of the various units are listed in Table 1.

Some of the equipment sizes have been brought about by assuming that this refinery, like many others, has been expanding stepwise since World War II. At the present time, the catalytic cracking unit has been expanded, and additional catalytic cracking capacity would have to consist of all new equipment. A current flow plan of the refinery when running the high-quality low-sulfur crude oil is shown in Figue 1.

In adding the high-sulfur crude oil to this refinery, it is both convenient and efficient to segregate the high-sulfur crude oil in one of the 25,000-barrel-per-day two-stage pipe stills. It is also convenient to produce all of the kerosine from the low-sulfur crude oil. In the case of the catalytic cracking unit, it is impractical to segregate the high- and low-sulfur gas oils via blocked operation. Thus all of the catalytic cracking products would be contaminated with the higher sulfur materials from the high-sulfur crude oil.

The high-sulfur crude oil which will be added to this refinery has an entirely different product distribution from the low-sulfur crude oil. This is shown in Table 2, which compares the crude-oil assays for the low- and high-sulfur crude oils. Of particular interest are the high yield of bottoms—30 vs. 4 percent—and the sulfur levels on some of the products. As might be expected, the replacement of 25,000-barrels-per-day of low-sulfur crude oil with high-sulfur crude oil creates substantial product debits. Table 3 compares the products which are obtained when running 100-percent low-sulfur crude oil with those obtained when running the 75:25 mixture of low- and high-sulfur crude oil. The high bottoms yield of the high-sulfur crude oil is reflected in the tripling of the heavy-fuel-oil yield—16½ vs. 5½ percent. The higher heavy-fuel-oil yield is at the expense of the gasoline and middle distillates for the most part—the gasoline-distillate yield having been reduced from 90,815 to 80,139-barrels-per-day. Because the refinery has developed a market for products based on the original product distribution, these major changes in the yield pattern will result in serious marketing problems. Therefore, it is most desirable to convert the incremental residual fuel into gasoline and middle distillates.

TABLE 1
Capacities of Major Refining Equipment

Pipe stills, bbl. per day	50,000 25,000 25,000
Viscosity breaking, bbl. per day	4,000
Hydroforming, bbl. per day	10,000
Polymerization, bbl. per day	5,500
Catalytic Cracking:	
Total feed, bbl. per day	80,000
Carbon burning, lb. per hour	31,650

TABLE 2
Comparison of Crude-Oil Assays

	Low-Sulfur Crude Oil		High-Sulfur Crude Oil	
Base classification	Intermediate		Intermediate	
Gravity, deg. API	36.8		25.7	
Sulfur, percent by weight	0.4		2.1	
Products	**Yield (Percent by Volume)**	**Sulfur (Percent by Weight)**	**Yield (Percent by Volume)**	**Sulfur (Percent by Weight)**
Gas, C_4 and lighter	2.1		1.2	
C_5 to 360 F FVT*	20.4	0.01	18.2	0.02
360 F to 530 F FVT	23.3	0.05	12.8	0.28
Total gas oil	50.2	0.60	37.8	1.8
Bottoms	4.0	1.20	30.0	4.5
	100.0	0.37	100.0	2.1

* FVT = final vapor temperature.

TABLE 3
Product Effects—Substitution of 25,000 Bbl Per Day of High-Sulfur Crude Oil for Low-Sulfur Crude Oil (Barrels per day)

	Low-Sulfur Crude Oil	75:25 Low- and High-Sulfur Crude Oil	Difference (Mixture —Low Sulfur)
Gasoline (10 lb. RVP)	51,938	49,731	— 2,207
Middle Distillate	38,877	30,408	— 8,469
Residual fuel oil	5,477	16,381	+10,904
Liquefied petroleum gas (C_3's and C_4's)	5,025	3,827	— 1,198

Coking of Residuum — The fluid coking process has been described in the literature[1] as a means of converting residual fuel oil into distillate products with relatively small yields of coke. Hence, the coking process should be applicable to this refinery to enable it to handle better the heavy high-sulfur crude oil.

In setting up a case including a fluid coker in this refinery, it was decided to coke only the 7,500 barrels of high-sulfur residuum. The low-sulfur residuum would continue to be thermally cracked for viscosity reduction and blended off with the heavy polymer bottoms from catalytic cracking to produce the heavy fuel needed to protect the requirements of the refinery's market.

Note: It should be mentioned, however, that there would be a very good return for increasing the size of the coker to handle all of the residuum,

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provided the refiner wishes to go out of the fuel business.

The total coker gas oil would then be fed to the catalytic cracking unit along with the low-sulfur and high-sulfur virgin gas oils. The flow plan for this operation is shown in Figure 2. The addition of coking to the refinery provides substantial improvements in yield structure, as shown in Table 4. It will be noted that the coking process has greatly increased the yield of middle distillates, at the expense mainly of fuel oil, with a small reduction in gasoline yield. As a matter of fact, the yield of gasoline plus middle distillate is nearly as high as that which would have been obtained when running all low-sulfur crude oil. The gasoline middle-distillate yield from this coking case is 90,064-barrels-per-day, whereas that from the low-sulfur crude oil alone is only about 800 barrels-per-day more—90,815-barrels-per-day. The reduction of about 2,200-barrels-per-day in gasoline stems from the fact that the coker gas oil from this particular heavy high-sulfur residuum—3.6 deg API, 4.5 percent sulfur—is a relatively high carbon producer, and it is being fed to a catalytic cracking unit with a carbon-burning limitation. This causes a drop in gasoline yield in the catalytic cracking unit, inasmuch as conversion must be reduced in order to lower carbon yield and stay within carbon-burning limitations. This reduction would not occur in a case in which a better feed was supplied to the coker or in which additional catalytic cracking carbon-burning capacity is available.

Although the yield structure from this case with fluid coking approaches that which was obtained with 100 per cent low-sulfur crude oil, the gasoline-middle-distillate ratio is lower. In addition, the higher sulfur crude oil has passed on its sulfur to the various products, and some desulfurization process is required. In order to obtain products approaching the quality of those produced with 100,000-barrels-per-day of low-sulfur crude oil, it will be necessary to desulfurize some or all of the coker naphtha, the heavy catalytic naphtha, and the catalytic heating-oil streams.

PROCESS ISSUE '55
18th Annual

In addition to desulfurization, the treating process should impart improved stability and combustion characteristics to the various products. Inasmuch as hydrogen is available from the 10,000-barrel-per-day hydroformer, the hydrofining process would seem to be particularly suited as a treating process here.

Meet the Authors

W. HOWARD WINSLOW joined Esso Standard Oil Company in 1940 as a project engineer in the Mechanical Engineering department at the company's Baton Rouge, La., refinery. Now head of the Fuel Products group in the refinery's Process Engineering department, he also served in the Mechanical and Technical department where he held a number of supervisory and technical positions. Winslow received his bachelor's degree in mechanical engineering at Purdue University in 1938, and completed his master's degree there shortly before joining the company.

Winslow

JOHN WEIKART presented the accompanying article before a session on processes during the recent meeting of the API Division of Refining. He is a graduate from Cornell University, where he received a degree in chemistry in 1941, and in chemical engineering in 1942. Following graduation he joined what is now Esso Research and Engineering Company, receiving an assignment to its Process Research division. His experience in the refining industry includes pilot-plant studies in the fields of hydrofining, polymerization, catalytic cracking and thermal cracking. He is now serving as section head for work on hydrotreating.

Weikart

Hydrofining Process — Hydrofining is a versatile process for product improvement and has gained wide acceptance on a variety of products.[2, 5]

As mentioned previously herein, treating is required on some or all of the coker naphtha, the heavy catalytic naphtha, and the catalytic middle distillates. In the case of catalytic cracking products the treating requirements are rather mild because, on the average, only 25 percent of these products came from the high-sulfur gas oils. Thus mild Hydrofining conditions are applicable. It is realized that the "average" products are not likely to be available as feed to the hydrofiner, inasmuch as previous experience has shown that the crude-oil run from day to day will vary substantially from the 75:25 ratio which is considered average. Thus some products will require more severe Hydrofining, and some products might even bypass Hydrofining.

The application of Hydrofining to this processing scheme is illustrated in Table 5. This table presents actual results from the Hydrofining of a mixture of coker naphtha and heavy catalytic naphtha. The product inspections shown were obtained on total hydrofined product after stripping and caustic-washing to remove hydrogen sulfide. No rerunning was used or is necessary.

It will be noted that mild Hydrofin-

TABLE 4
Effect of Coking on Product Distribution (Barrels per day)

	No Coking	With Coking	Difference (Coking —No Coking)
Gasoline (10 lb. RVP)	49,731	47,552	— 2,179
Middle distillates	30,408	42,512	+12,104
Residual fuel oil	16,381	4,827	—11,554
Liquefied petroleum gas (C₃'s and C₄'s)	3,827	3,869	+ 42
Coke, FOE*	.....	1,307	+ 1,307

* FOE = fuel-oil equivalent.

TABLE 5
Hydrofining Mixture of Coker Naphtha and Heavy Catalytic Naphtha

	Feed Stock	Product
Sulfur, percent by weight	0.30	0.12
Bromine number, eg per g	41	33
Gravity, deg API	39.2	40.1
General Motors gum content (mg per 100 ml):		
No inhibitor	45	6
With 1 lb. per 5,000 gal.*	35	8
ASTM breakdown (2 lb. per 5,000 gal*), min.	200	1,000+
CFR Research octane number:		
Without TEL addition	89.0	88.5
With 2 ml TEL per gal.	93.0	93.5

* Phenylene diamine type.

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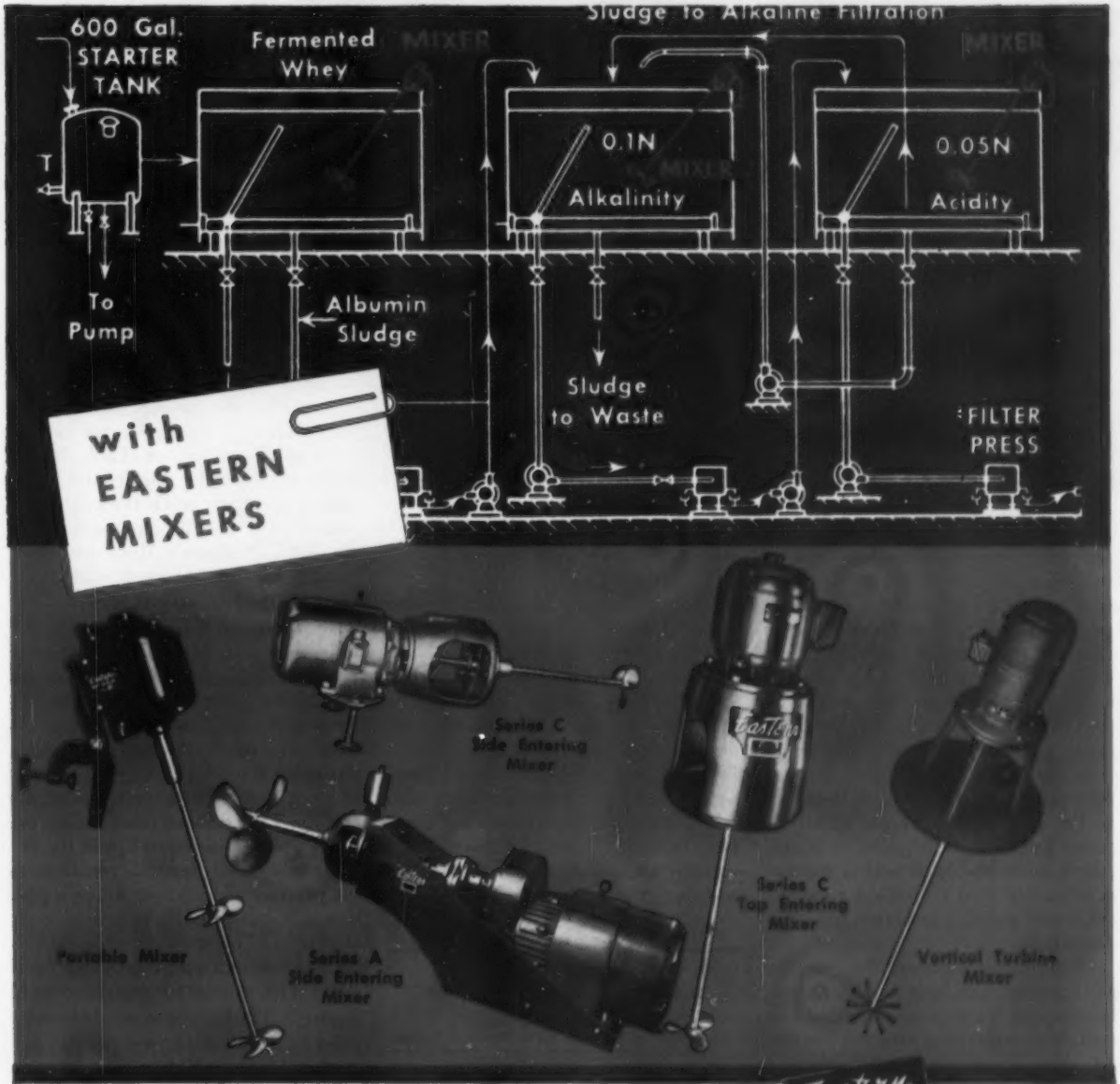

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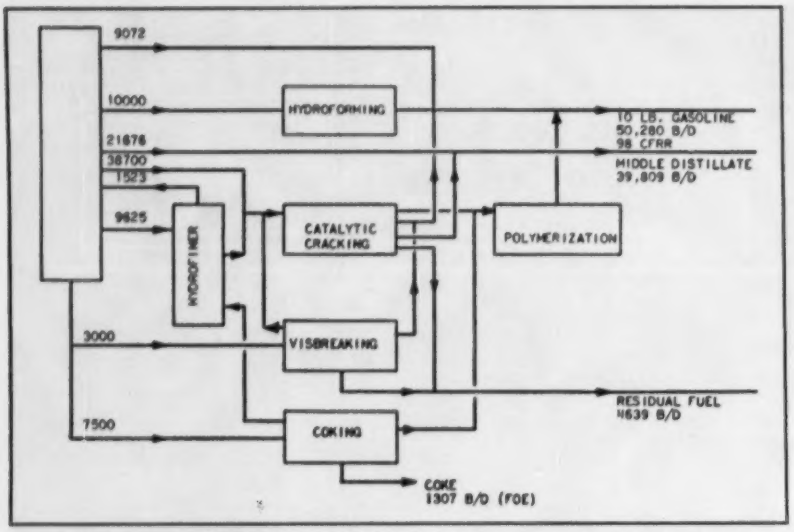

FIGURE 3—Simplified flow plan with hydrofining of cat cracking feed stock.

ing conditions provided 60-percent desulfurization with no loss in CFR Research octane number, with 2 ml TEL per gal. Stability, as evidenced by gum content and breakdown, was improved to an acceptable level for a gasoline component. More severe treatment would have provided a greater gum-content reduction. The yield from these operations is 100 percent by volume, and there is no loss as would be the case with a process which requires rerunning. Hydrogen consumption is quite low, well within the approximately 9 to 10 million standard cubic feet per day available from hydroforming.

Hydrofining improves the stability and burning characteristics of catalytic heating oils. Table 6 shows actual Hydrofining results on a catalytic heating oil. Here again, yield is 100 per cent by volume, and no rerunning is necessary. Carbon residue on 10-percent bottoms is indicative of burning characteristics and soot and carbon deposition. It will be noted that Hydrofining provides substantial improvements. This is particularly true when it is considered that heating oils are often stored and, hence, they age prior to use. On the basis of aged heating oils, the hydrofined product has a carbon-residue value of 0.04, vs. 0.45 for the raw heating oil.

Hence, Hydrofining provides a tenfold improvement. It will be noted that there is practically no sulfur removal in this operation. Sulfur could have been reduced if desired by making the operation a little more severe.

Hydrofining of Catalytic Cracking Feed Stock—The virgin gas oil and coker gas oil derived from the high-sulfur crude oil are the main source of sulfur problems in the distillate products. Thus it would appear desirable to desulfurize the gas oils prior to catalytic cracking and thereby avoid product-finishing problems. It would also avoid corrosion problems in the catalytic cracking unit which would not contain alloy corrosion protection. In addition, the amount of desulfurization feed stock is only about 13,000-barrels-per-day—coker products plus high-sulfur virgin gas oil—vs. up to 25,000-barrels-per-day of products which require Hydrofining.

TABLE 6
Hydrofining Catalytic Heating Oil

	Feed Stock	Product
Sulfur, percent by weight	1.2	1.1
Carbon residue (10-percent bottoms), percent by weight	0.09	0.04
Blending value, percent by weight	0.45	0.04
After storage, percent by weight	0.45	0.04
Color, Tagluabue-Robinson	13	17

TABLE 7
Effect of Hydrofining on Mixed Virgin and Coker Gas Oil

	Feed Stock	Product
Gravity, deg. API	21.8	26.6
ASTM distillation (at 10 mm. of mercury converted to 760 mm), fahrenheit:		
10-percent point	557	545
30-percent point	680	655
50-percent point	763	744
70-percent point	867	843
Distillation discontinued	964	985
Recovery, percent by volume	85	89.5
Aniline point, Fahrenheit	159	167
Refractive index at 66 C	1.5019	1.4875
Conradson carbon, percent by weight	1.0	0.2
Sulfur, percent by weight	2.33	0.40
Nitrogen, percent by weight	0.07	0.04

The Hydrofining process is also applicable to gas-oil feed stocks. A gas oil which is treated in this process is substantially improved in catalytic cracking quality. Hydrofining of gas oil reduces Conradson carbon, lowers the sulfur content, decreases the gas-oil aromaticity, and removes some of the metal contaminants. These improvements in gas-oil quality permit increased conversion in a catalytic cracking unit for the same carbon-burning rate. Improved gasoline yields and octanes are also obtained. Table 7 compares a high-sulfur virgin and coker gas-oil mixture with its hydrofined counterpart. It will be noted that sulfur and Conradson carbon, and other inspections indicative of catalytic cracking quality, are improved.

In setting up the hydrofiner for this refinery it was decided to hydrofine both the high-sulfur virgin gas oil and high-sulfur coker gas oil before feeding them to the catalytic cracking unit. It would also appear desirable to include the coker naphtha in the hydrofiners in order to desulfurize and upgrade its quality. The effluents from the hydrofiners would be separated, and the desulfurized coker naphtha returned to the primary rerun tower where a portion of it would end up in hydroformer feed stock. The total gas oils would be sent to the catalytic cracking feed tanks. This process scheme is shown in Figure 3. The hydrogen would be supplied by the 10,000-barrel-per-day hydroformer and would amount to about 9,000,000 to 10,000,000 standard cubic feet of hydrogen per day. Based on total feed to the hydrofiner (13,500-barrels-per-day), this hydrogen availability would amount to about 700 standard cubic feet per barrel. This is ample for this particular application.

Hydrofining of the catalytic cracking feed stock provides significant improvements in yield distribution compared to the previous case of coking and Hydrofining products. This is shown in Table 8. It will be noted that the middle-distillate plus gasoline yield is about the same as for the case without desulfurizing feed stock, viz., 90,-

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089-barrels-per-day vs. 90,064-barrels-per-day. However, Hydrofining of the catalytic cracking feed stock has upgraded about 2,700-barrels-per-day of middle distillate to gasoline. About 700-barrels-per-day of additional liquefied petroleum gas also is obtained. Thus the Hydrofining of catalytic cracking feed stock has improved the product distribution by making 2,700-barrels-per-day more gasoline, and 700-barrels-per-day more liquefied petroleum gas. This has been done largely at the expense of heating oil, inasmuch as kerosine and diesel fuel have been kept constant. In addition to the yield improvements, the quality of the products is such as to require minimum treating. As a matter of fact, the treating requirements here are about the same as for a refinery running all low-sulfur crude oil. Furthermore, the use of the catalytic cracking feed-stock hydrofiner provides a less corrosive atmosphere in the catalytic cracking unit and the associated light-ends plants. This reduces maintenance and the need for corrosion-resisting alloy equipment and linings.

Investments and Economics — The substitution of 25,000-barrels-per-day of high-sulfur crude oil for a like amount of low-sulfur crude oil will require some additional plant investment, viz., about $1.3 million onsite and offsite for alloy corrosion protection at the pipe still and catalytic cracker and for hydrogen-sulfide removal equipment in the light-ends plant. A diethanolamine plant plus regenerator was assumed. Operating costs would also increase to the extent of $300,000 per year.

The investments used here and in the subsequent cases cover onsite and offsite facilities. They are based on average industry design standards.

The addition of a fluid coker, product hydrofiners, and associated equipment requires an additional $8 million investment, and operating costs are increased by $2 million per year. In the case of Hydrofining, two units have been included—one unit to process coker naphtha plus heavy catalytic naphtha and the other to process catalytic heating oil. Economies could probably be realized, at the sacrifice of flexibility, by the use of a single large hydrofiner.

Hydrofining of catalytic cracking feed stock requires more severe operating conditions than those for catalytic products because of the higher sulfur in the feed stock and because of the high boiling range. On the other hand, the amount of hydrofiner charge is reduced. Although Hydrofining catalyst does not normally require regeneration, severe treatment of heavy high-sulfur coker gas oil sometimes causes slow deactivation. Thus periodic regeneration will probably be required in the case described here. It was felt that it would be better to be conservative, so investment for regeneration equipment has been included. Removal of sulfur before catalytic cracking cuts down on the need for corrosion-resistant alloys in the catalytic cracking unit. The investment for coking and Hydrofining catalytic cracker feed stock is $2.3 million more than for coking and product Hydrofining.

The economics of these operations are summarized in Table 9. They have been based on *Platt's Oilgram* "lows" for mid-December 1954 for Gulf Coast cargoes. For example, 95-CFR-Research-octane-number gasoline has been valued at 12 cents per gallon, and No. 2 heating oil at 8.5 cents per gallon.

As mentioned previously herein, Table 4 shows the change in product distribution obtained by adding a fluid coker and products' hydrofiners to a refinery processing a 25:75 mixture of high- and low-sulfur crude oils. Based on *Platt's Oilgram* "lows," the increase in product value is $5.2 million per year. After the added operating costs of $2 million per year have been deducted, the remaining $3.2 million per year provides a 40-percent return on the $8 million added investment. This return is calculated before income taxes.

The change in product distribution for Hydrofining catalytic feed stock rather than catalytic cracking products is shown in Table 8. The change provides an increase in product value of $2.8 million per year, or $8 million per year more than the refinery case without fluid coking. The $2.8 million added value was obtained with an additional investment of $2.3 million and an additional operating cost of $600,000 per year. This provides 96-percent return per year on the $2.3 million investment. The $8 million increase in product value was obtained by adding $10,300,000 in investment—the fluid coker, the catalytic cracking feed-stock hydrofiners, and the like — with an added operating cost of $2.6 million per year. This provides a 52-percent return before taxes on the entire coking-plus-Hydrofining investment. This 52-percent return on the investment shows that fluid coking and Hydrofining provide an economic method of processing a high-sulfur crude oil in a low-sulfur refinery.

TABLE 8

Advantages for Hydrofining Catalytic Cracking Feed Stock (Barrels per day)

	Hydrofining, Catalytic Cracking Feed Stock	Hydrofining, Catalytic Cracking Products	Difference (Hydrofining Feed —Hydrofining Products)
Gasoline (10 lb. RVP)	50,280	47,552	+2,728
Middle distillates	39,809	42,512	—2,703
Residual fuel oil	4,639	4,827	— 188
Liquefied petroleum gas (C3's and C4's)	4,594	3,869	+ 725
Coke, FOE	1,307	1,307	.....

TABLE 9

Summary of Economics

	No Coking, No Hydrofining	Coking and Product Hydrofining	Coking and Hydrofining of Catalytic Cracking Feed Stock
Incremental investments* (Onsite plus offsite), millions of dollars:			
Over low-sulfur crude-oil refinery	1.3	9.3	11.6
Over refinery with no coker	....	8.0	10.3
Incremental operating costs, millions of dollars per year:			
Over low-sulfur crude-oil refinery	0.3	2.3	2.9
Over refinery with no coker	....	2.0	2.6
Incremental product value over no-coking case, millions of dollars per year	....	5.2	8.0
Return on investment no-coking case, percent	....	40	52

* Based on average industry design standards.

Original presentation was before the Division of Refining API meeting, St. Louis, May 11, 1955.

ACKNOWLEDGMENT

The authors wish to thank their colleagues on the technical staffs of Esso Standard Oil Company, Louisiana division, and of Esso Research and Engineering Company for their help and guidance in preparation of this paper. Particular thanks are extended to M. C. Sussky of Esso Standard Oil Company for his help in carrying out the calculations needed to set up the refinery cases.

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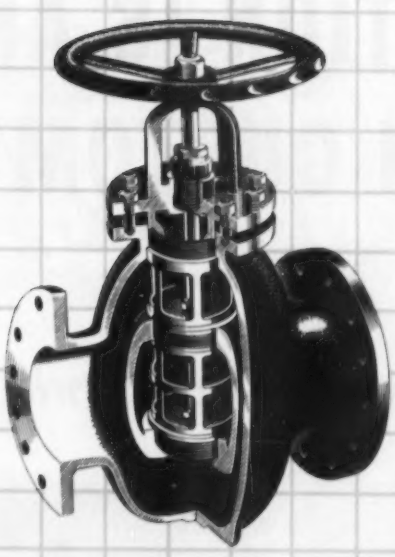

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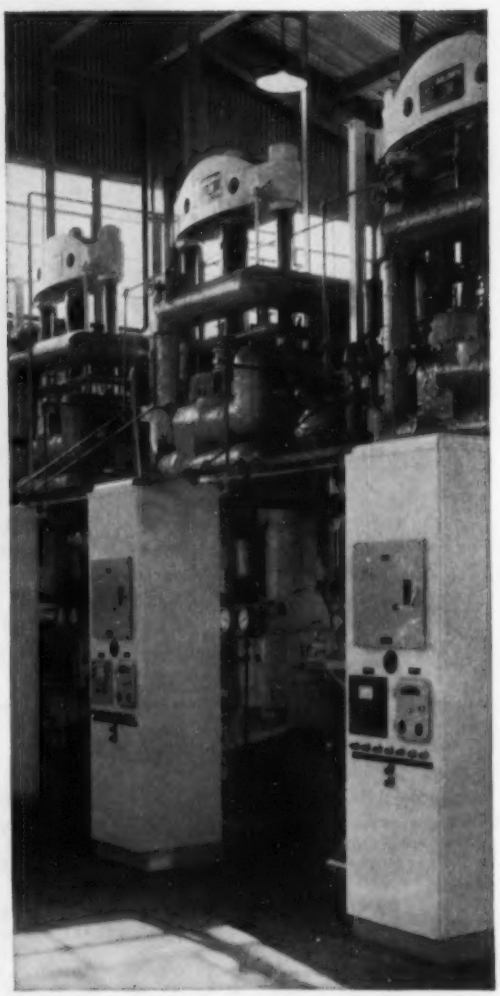

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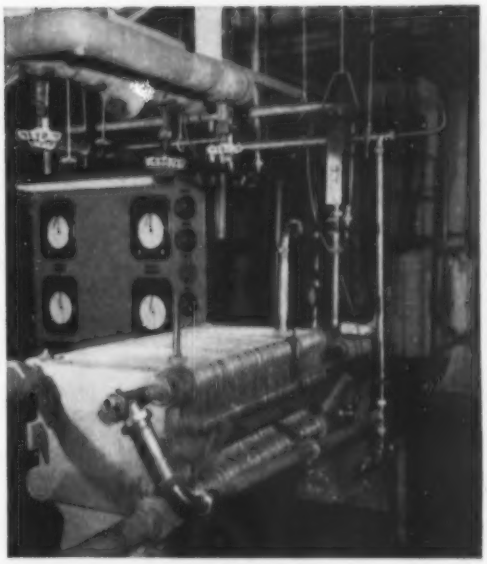

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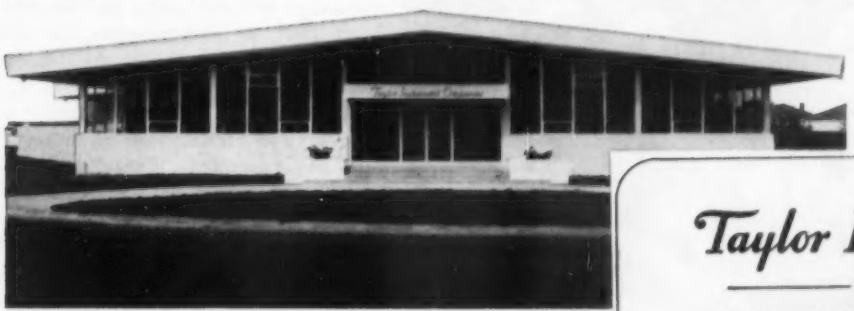

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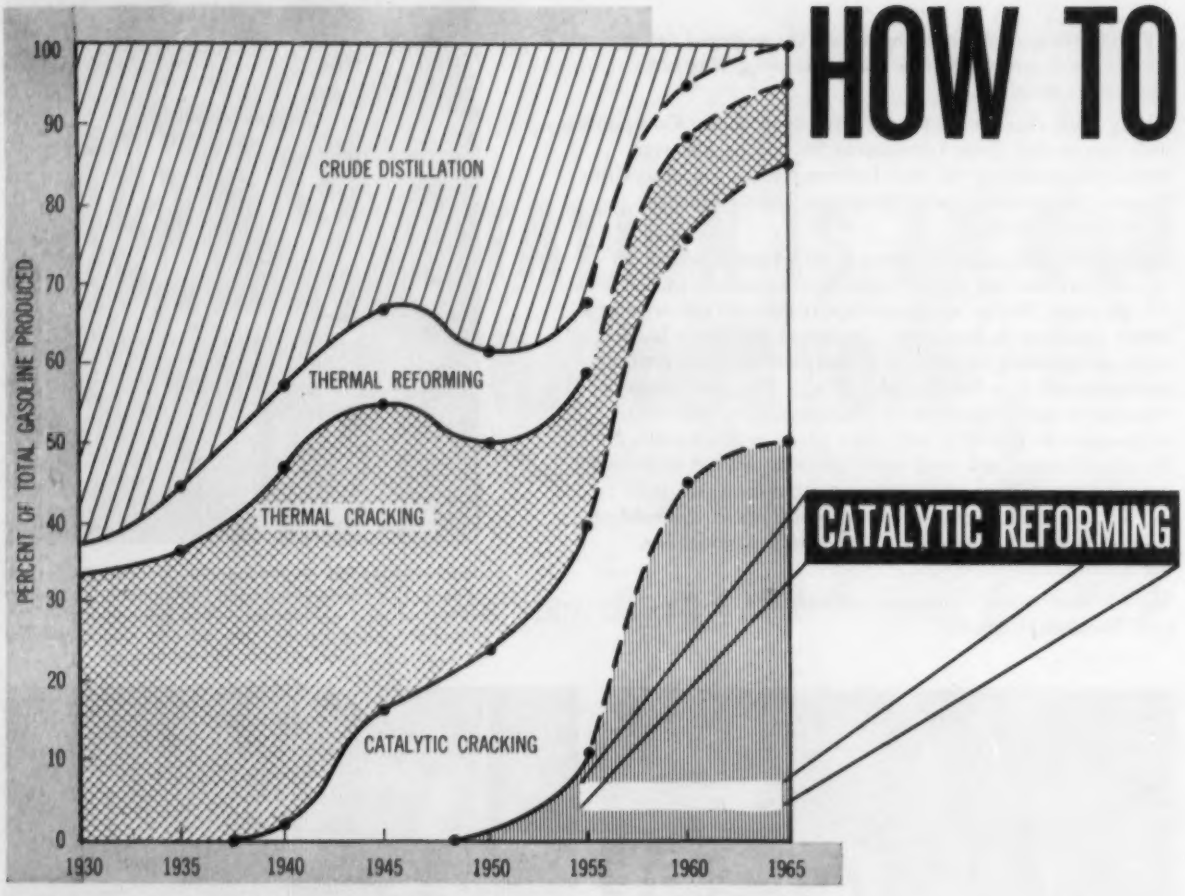

FIGURE 1—Trends in processes for making gasoline: Catalytic reforming will take a 50 percent bite in 1965.

Meet the Authors

Sittig Warren

MARSHALL SITTIG will be remembered as author of the 54-page report, "Catalytic Cracking Techniques in Review," appearing in the Petroleum REFINER for September 1952. Now in Ethyl Corporation's New York office where he furnishes technical assistance to the company's sales force, Sittig first became interested in the petroleum industry while still an undergraduate in chemical engineering at Purdue University. That interest carried him to the Du Pont organization where he spent several years in manufacturing and research and later to Detroit where he did technical writing and editing for Chrysler Corporation.

WAYNE WARREN was co-author of the paper entitled, "Fuel Knock Behavior in Passenger Cars," delivered at the WPRA meeting in San Antonio this spring. Warren serves Ethyl Corporation as head of its Refinery Technology group at the Detroit research laboratories. He formerly was connected with The Texas Company and Humble Oil & Refining Company, served in the Navy and worked part time for the Petroleum Administration for Defense.

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INCREASES IN OCTANE requirements of new vehicles coupled with a competitive gasoline market are driving octane numbers to new high values. This is a matter of serious economic concern to petroleum refiners and this article will make a particular attempt to highlight the economics of producing those last few octane numbers now necessary to satisfy new-model high compression engines or to meet a particular marketing situation.

Octane numbers of some premium fuels now being marketed in the East and Southwest are in the range of 97-98 by the Research (F-1) method.

The trends for all United States refineries in terms of pool, regular, and premium octane numbers are shown in Table 1.

As motor fuels have increased in quality, it has become necessary to constantly change the type of processing employed to produce these fuels. This trend is shown graphically in Figure 1, from data published by Lyman.[199]

As shown there, straight-run distillation gave way to thermal cracking and that process in turn has given away to catalytic cracking as the work horse of the industry for gasoline manufacture.

Catalytic cracking has been reviewed in detail in a series of articles by Sittig[280, 281, 282, 283, 284, 285] and in a recent monograph by Shankland.[277]

Murphree et al[226] states: "Catalytic cracking is conducted primarily to produce gasoline and middle distillates from fractions formerly discarded in fuel oil. The octane number gained by the application of the process is

It's all here

	PAGE
All about reforming ...	232
Feed stocks	232
Feed preparation	232
Chemistry	234
Sulfur compounds	237
Process variables	238
Catalysts	239
Aromatics recovery	242
Thermal reforming	242
Polyforming	243
Catalytic reforming	243
Consider also isomerization	259
Dollars and cents of octane improvement	260
Can you save with TEL?	262
What reforming processes give	263
Poly and alkylate play a part.	275
Don't forget process combinations.	276
PLUS 329 references .	278

thus, in a sense, a valuable by-product."

Murphree et al[226] goes on to state that during the 1920-1940 period, the octane numbers of the fuels marketed were increased partly by increasing the TEL content and partly by thermally reforming low-grade virgin naphthas. Murphree traced octane improvement for a hypothetical refinery as follows: grades of 88 and 82 RON (2.75 cc TEL per gallon premium, 2.0 in regular), with thermal reforming and cracking; grades of 94 and 88 RON with catalytic cracking, no reforming; grades of 98/92 RON upon thermal reforming with catalytic cracking; and grades of 100/94 RON upon replacing thermal reforming with catalytic reforming.

At the moment, with catalytic cracking firmly established as a source of high-octane base stocks, emphasis has turned to the economic attainment of the last few octane numbers required for today's and tomorrow's motor fuels. This involves octane improvement through high-octane blending agents made by reforming, isomerization, alkylation or polymerization.

As outlined by Rawlings,[252] the steps toward higher octanes are as follows:

1. More catalytic reforming.
2. More severe catalytic cracking operations to provide additional unsaturates for alkylation unit feed.
3. More alkylation.
4. New extraction processes which will increase the aromatic content of the blending stock.
5. More polymerization.
6. More isomerization to upgrade C_5 and C_6 components.

Considering a basic refinery to contain only thermal cracking and thermal reforming as conversion processes, Parker[241] presented an octane-yield evolution based on incorporating post war processing. His summary is presented in modified form in Table 2.

Draeger, et al[79] have offered an illustrative example of the cumulative effect of sequential addition of selected processing in producing high octane motor gasoline from an average crude, as shown in Table 3.

Depending on the specific octane improvement problem, the economic answer usually consists of a combination of TEL utilization and various processing steps.

All About Reforming . . .

In 1925, straight-run naphtha of low quality was used directly as motor gasoline. Not long after that, thermal rearrangement or reforming of naphtha molecules for octane number improvement was first used. Reforming differs from cracking basically in that naphthas are the charge stocks for reforming, whereas gas oils or reduced crudes are the charge stocks to cracking plants. It should be noted that the term reforming also has been applied to the cracking of hydrocarbons, alone or in the presence of steam, to produce fuel gas or synthesis gas. In this article, however, reforming will be confined to the rearrangement of naphtha molecules for octane improvement as described in detail in the following section on hydrocarbon chemistry.

A general comparison of the various reforming processes available to the industry today is shown in Table 4. In this table, thermal reforming and all of the various catalytic reforming processes are compared with respect to operating conditions.

The choice of a catalytic reforming process necessitates an evaluation of many of these characteristics since the particular process to produce a desired product from a given charge varies with the exact refinery situation.

The British Catarole process will not be discussed in this article because it is directed primarily to the production of chemical intermediates rather than to the production of high-octane fuels.

TABLE 1—Pool Octanes and Estimated Premium-Regular Octane Numbers

TEL—ml/gal	End 1953		End 1954		End 1955		
	Pool	Prem/Reg	Pool	Prem/Reg	Pool	Prem/Reg	Prem/Reg*
2.2	88.0	92.9/85.9	89.3	94.2/87.2	90.8	95.7/88.7	95.0/88.0
3.0	89.4	94.3/87.3	90.7	95.6/88.6	92.1	97.0/90.0	96.3/89.3

Basis: 1. Research Octane; 2. 10.2 psi Reid Vapor Pressure; 3. 85% Catalytic Reforming Severity; 4. 80% Thermal Reforming Severity; 5. RON Premium minus RON Regular—7.0; 6. 70% Regular—30% Premium (except where indicated).

* 60% Regular—40% Premium.

Also, although the Catarole process produces large amounts of aromatics, it produces them through a basically different mechanism than does catalytic reforming. In hydroforming, naphthenes are isomerized and dehydrogenated to aromatics in a relatively mild rearrangement process. In the Catarole process on the other hand, severe cracking gives butadiene and ethylene which combine by a Diels-Alder type of reaction to give benzene.

Reformer Feed Stocks

Virgin naphthas are the major feed stocks to reforming processes, although cracked naphthas, natural gasolines and even some paraffinic raffinates may constitute reformer feed materials. Table 5 shows the chemical compositions of some typical naphthas, as adapted from Teter, Borgerson and Beckberger.[297]

Successful experience has been reported in the reforming of a wide variety of charge stocks. Catalytic reforming of olefin-containing stocks such as thermally-cracked gasolines is usually best accomplished by reforming a mixture of such stocks with virgin naphthas; the admixture of approximately an equal part of straight-run material is necessary to produce an adequate amount of recycle hydrogen for the reforming process. Catalytic reforming of catalytically-cracked gasolines gives a good source of aviation gasoline base stocks, as described by Read.[257] Weinert et al[320] have presented data on platinum reforming of a blend of 70 percent coker distillate and 30 percent virgin naphtha.

The catalytic reforming of natural gasoline has been discussed by Fulton,[105] by Sutherland and Hanson[293] and by Williams and Sutherland.[323]

Reformer Feed Preparation

Reformer feed preparation falls into three broad operations:

1. Prefractionation with control of feed end-point to avoid excessive carbon laydown on the catalyst.

TABLE 2—Octane Yield Evolution With Various Processing Variations

OPERATION	Vol. Percent on Crude	RON, Clear
Basic Refinery Gasoline Pool	40.0	70.0
Considered Separately:		
Alkylate C_3 and C_4 from Reforming and Cracking	+10.0	+3.8
Isomerize Pentanes	....	+2.0
Replace Thermal with Catalytic Cracking, same yield	....	+5.5
Replace Thermal with Catalytic Cracking Designed for Maximum Yield	+10.0	+6.5
Polymerize C_3 and C_4 olefins	+ 4.0	+6.5
Hydroform in lieu of Thermal	+ 2.0	+6.0

2. Saturation of olefins.

3. Removal of non-hydrocarbon contaminants consisting of sulfur compounds, nitrogen compounds, water and metals (particularly arsenic and lead).

The hydrogenation of olefins to paraffins is necessary in platinum catalyst processes; in molybdenum hydroforming, prehydrogenation is not necessary. Many of the non-hydrocarbon constituents of naphthas are harmful to certain reforming catalysts and hence, feed stocks must be treated to remove these materials.

The removal of contaminants may be accomplished by various means. In reporting on a new Platforming unit for Bell Oil and Gas Company, Ziegenhain[328] discussed a feature by which catalyst poisoning was overcome. Four towers filled with fuller's earth were described as the treating equipment. An excellent discussion of clay pretreating has recently been published.[221] In Houdriforming operations, a "guard case" has been employed to protect the plant reactors from contaminants. This guard case is a small reactor containing platinum catalyst which removes sulfur compounds (as H_2S), removes lead and copper salts, and also hydrogenates any olefins present in the feed.

Since some of these materials are active catalyst poisons even when present in very low concentrations, the precise

TABLE 3—Cumulative Effects of Additional Processing Steps On Yields and Octane Numbers

Step	OPERATION	C_5—400 F. GASOLINE Vol. Percent Crude	RON	MON
1	Virgin Naphtha (Crude)	25.0	55	53
2	Thermally Crack Gas Oil & Residuum	42.7	61	57
3	Cat Cracking vs. Thermal	44.6	70	63
4	Thermally Reform 200-400 F.	41.2	83	73
5	Hydroform vs. Thermal	42.4	86	76
6	Non-Selective polymer, C_3, C_4	42.2	86.5	76
7	Alkylation (incl. C_3) vs. Polymer	42.8	87	78
8	Remove nC_5, nC_6, nC_7	37.0	91	82
9	Isomerize nC_5, nC_6	40.6	90	82
10	Remove raffinate (hydroformate)	37.1	95	85
11	Thermally reform raffinate and nC_7	39.8	94	84
12	Vacuum flash, deasphalt, cat cracking, and attendant processes	60.7	94	85

Gasoline pool composition:

COMPONENT	Vol. Percent Crude	RON	MON
Cat Naphtha, C_5-400	22.4	92	78
Alkylate, C_3, C_4, C_5	11.6	92	91
Isopentane	3.6	88	88
Isohexanes	3.6	81	80
Isoheptane fraction	3.1	72	71
Extracted Toluene	1.8	120	110
Extracted Xylenes	3.5	140	120
Heavy Aromatics	2.9	100	80
Reformed raffinates + nC_7	2.7	74	64
Extraneous n-butane	6.0	95	95
Total pool	60.7	94	85

TABLE 5—Feed Stock Characteristics

CRUDE SOURCE	Mid-Continent	Venezuela	Kuwait	Pennsylvania	Gulf Coast
Gravity, °API	34.1	28.6	34.0	37.4	28.1
IBP, °F	236	252	240	214	202
10 Percent	257	273	283	232	250
50 Percent	291	306	310	260	305
90 Percent	341	358	337	308	356
EP	373	385	355	336	394
Naphthenes, Vol. Percent	43.2	43.0	19.4	27.7	55.5
Aromatics, Vol. Percent	7.7	22.9	14.7	11.1	18.5
Paraffins, Vol. Percent	48.8	33.8	65.1	58.8	26.0
Sulfur, Wt. Percent	0.021	0.032	0.087	0.072	0.02
Octanes, Research:					
Clear	36.5	51.0	29.6	43.4	59.4
3 ml. TEL	61.0	73.0	52.5	65.5	.....

TABLE 4—Comparison of Reforming Processes

PROCESS	Thermal Reforming	USING MOLYBDENUM CATALYSTS: Fixed-Bed Hydroforming (M. W. Kellogg Co.)	USING MOLYBDENUM CATALYSTS: Fluid Hydroforming (M. W. Kellogg Co.) (Esso Res. & Eng. Co.) (Std. Oil Co. (Ind.))	USING MOLYBDENUM CATALYSTS: Hyper-Forming (Union Oil Co. of Cal.)	USING PLATINUM CATALYSTS: Non-Regenerative (Platforming-UOP)	USING PLATINUM CATALYSTS: Occasionally Regenerative*** (Catforming Atlantic Refining Co.) (Houdriforming-Houdry Process Corp.) (Process of Esso Res. Eng.) (Savaforming-Socony-Mobil Oil Co.)	USING PLATINUM CATALYSTS: Cyclically Regenerative*** (Ultraforming-Std. Oil Co. (Ind.)) (Sinclair-Baker-Kellogg Process)	USING OTHER CATALYSTS: Thermofor Catalytic Reforming (TCR) (Socony-Mobil Oil Co.)	USING OTHER CATALYSTS: Cycloversion (Phillips Petroleum Co.)	USING OTHER CATALYSTS: Isoforming Std. Oil Co. (Ind.)
CATALYST	None	Pellets	Powder	Pellets	Pellets	Pellets	Pellets	Beads	Pellets	Pellets
Bed Type	.....	Fixed	Fluidized	Moving	Fixed	Fixed	Fixed	Moving	Fixed	Fixed
Chem. Compn.	.....	10% MoO_3 on Al_2O_3	10% MoO_3 on Al_2O_3	Cobalt Molybdate	Pt + Halogen + Al_2O_3	0.5% Pt on Al_2O_3*	on Al_2O_3	Cr_2O_3 + Al_2O_3	Bauxite	Clay
Catalyst Life	.....	9-12 mos.	0.1 Lb./Bbl.	.....	.....	20-100Bbls./Lb.	40-200Bbls./Lb.	.....	.....	6 Mos.
Catalyst Cost, $/Lb.	.....	0.89	0.585	1.30	(11.00 Initial Chg; 4.00 Replacement)			.....	.....	0.20
REACTION Temp., °F.	950-1050	1000	890-940	870	850-950	900-950	900-950	950-1000	950-1000	950
Pressure, psi	250-1000	150	200	400	200-700	300-400	200-500	100-200	50-57	10-20
Space Velocity, W/W/Hr.	.....	0.6	0.3-1.0	1.0	1-4	1-4	1-5	0-7	1.0-2.0	.....
Contact Time, Sec.	10-20	13	.....	.....	.....	.....	.....	.....	.....	.....
Recycle Gas/Feed Ratio	None	3/1 to 8/1	5/1 to 8/1	.....	.....	.....	3/1 to 10/1	3/1 to 9/1	None	None
Recirc. Rate, Ft^3/Bbl.	.....	2000-6000	4000-6000	3600	.....	.....	.....	.....	None	None
Recirc. Gas, % H_2	.....	70	60-70	65	.....	80-95	.....	50-60	.....	.....
Catalyst/Oil Ratio	.....	.....	0.5-1.0	0.05	.....	.....	.....	.....	.....	.....
REGENERATION TYPE	None	Cyclic	Separate	Separate	None	Occasional	Cyclic	Separate	Cyclic	Cyclic
Regen. Temp., °F.	.....	1100	1100	950	.....	1050	.....	800-1000	.....	1050
Regen. Press., psi	.....	170	200	415	.....	250-300**	.....	.....	15	
Regen. Gas Comp.	.....	1.5% O_2 in F.G.	Air	2% O_2 in F.G.	.....	O_2 in F.G.**	.....	Air	Air in Steam	5% O_2 in F.G.
Time Between Regens.	.....	2-12 Hrs.	Continuous	Continuous	Years	2-5 Mos.	7.5 Bbl./Lb.	Continuous	18-36 Hrs.	48 Hrs.

* Except Catforming: Pt. on SiO_2-Al_2O_3. ** Except Catforming: Dilute Air + Steam at Atmos. Press.
*** Approximate figures for each type of process. Not necessarily pertinent to any one specific process.

TABLE 6—Changes in Hydrocarbon Composition Effected by Catalytic Reforming*

COMPONENT	VOLUME PERCENT	
	Before Reforming	After Reforming
Aromatics	10	50
Naphthenes	40	4
Isoparaffins	25	28
n-Paraffins	25	18

* Anon.[4]

determination of impurities is vital. Since the presence of even trace quantities of nitrogen compounds in feed stocks can seriously reduce the activity of platinum catalysts, workers at Sun Oil Company have developed a technique for determination of total nitrogen in reformer charge stock as described by King and Faulconer.[187] Similarly, workers at Ethyl Corporation[99] have published a method for the determination of trace quantities of lead in gasolines and naphthas.

Sulfur content of feeds to molybdenum catalyst processes may be quite high but feeds to platinum catalyst processes must be well below 0.1 percent sulfur. Pretreatment of reformer feeds with by-product hydrogen is discussed further under the section on "By-Product Hydrogen." See also the section on "Behavior of Sulfur Compounds" on this general topic. The effect of sulfur on platinum catalyst life has been discussed by Meerbott et al.[218]

The question of catalyst tolerance to water varies with specific reforming catalysts. However, as discussed under "Platinum Catalysts," water addition to Platformer feed may be used to decrease hydrocracking in a controllable manner.

There have been claims made that some platinum catalyst compositions are resistant to arsenic but operating experience has given considerable evidence of a very low tolerance for arsenic in feed stocks to such processes.

Lead contamination of charge stocks to platinum catalyst must be held to a bare minimum.

Hydrocarbon Chemistry

The reactions involved in the hydroforming of naphthas have been discussed by Greensfelder, Archibald and Fuller[116] and by Herington and Rideal.[161]

The general classes of reactions which are involved in hydroforming are reviewed by McGrath and Hill.[216] The relative extent to which these various reactions occur is a function of operating conditions, feed stock, and condition of catalyst.

1. Dehydrogenation of C_5 and C_6 naphthenes to aromatics as typified by these reactions.

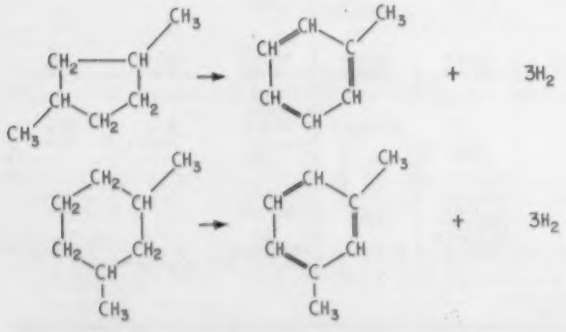
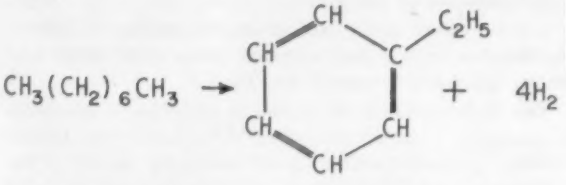


TABLE 7—Summary of Reaction Rates for n-Heptane Hydroforming Over Platinum[164] (r_o = initial rate of conversion; $r_o = r_1 + r_2 + r_3$).

Temp. °F.	Pressure psig.	G. MOLES/G. CAT/HR.					
		nC_7 Disappearance r_0	Hydrocracking r_1	Isomerization r_3	Dehydrocyclization r_2	Aromatization	
						MCH r_4	DMCP'S r_5
925	500	0.30	0.10	0.16	0.04	0.95	....
925	350	0.28	0.08	0.15	0.05	....	....
925	200	0.26	0.05	0.13	0.06	0.95	0.13
875	500	0.18	0.05	0.12	0.01	....	....
875	200	0.16	0.04	0.09	0.02	....	....

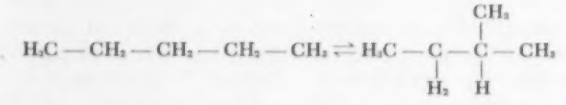
2. Dehydrocyclization of paraffins and olefins to aromatics



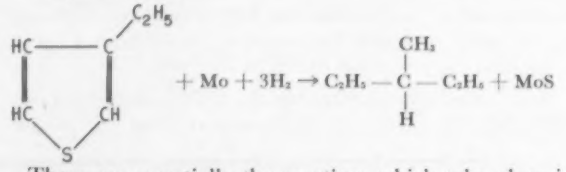
3. Hydrocracking producing saturated hydrocarbons

$$n\text{—}C_{12}H_{26} + H_2 \rightarrow C_2H_6 + n\text{—}C_8H_{18}$$

4. Isomerization of paraffins to branched-chain products



5. Desulfurization, as shown by the following reaction of ethylthiophene



These are essentially the reactions which take place in fluid hydroforming as well as in platinum reforming. One representation of the changes effected by these reactions is given in Table 6.

Haensel and Grote[138] have presented data showing that dehydrogenation is a faster reaction than isomerization and that isomerization in turn is faster than hydrocracking. Rate data for the various hydroforming reactions are given in Table 7 as published by Hettinger, Keith, Gring and Teter.[164]

The reforming of pure compounds over commercial catalysts gives valuable indications of performance, as discussed by Heinemann, Schall and Stevenson[155] and offers a good means of testing catalyst activity for certain reactions. The conclusions drawn from pure-compound studies are, of course, not entirely applicable to the complex mixtures in commercial feed stocks. In the latter case, the various types of hydrocarbons compete for the active sites on the catalyst.

Beyler, Stevenson and Shuman[45] disclose that the predominant reactions which occur in catalytic reforming (over the Houdriforming catalyst) are reaction velocity controlled at the conditions used. This simplifies the design of commercial plants from pilot plant data, according to these authors. Other data indicates dehydrogena-

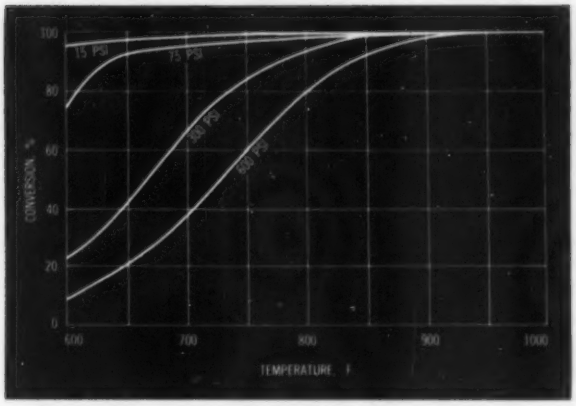


FIGURE 2—Pressure effect on MCH conversion.

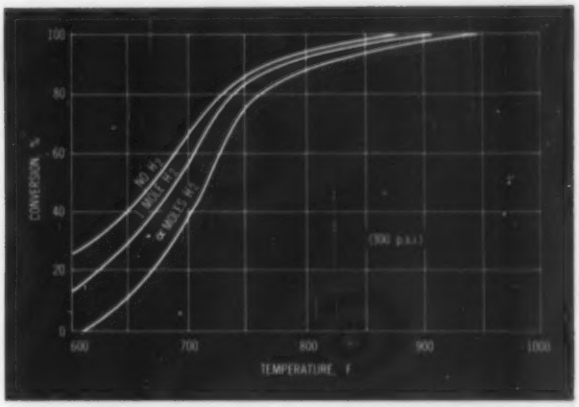


FIGURE 3—Hydrogen effect on MCH conversion.

tion to be diffusion-controlled, however.

Dehydrogenation of Naphthenes—Dehydrogenation of naphthenes to aromatics is a highly endothermic reaction and a very rapid one. The reaction results in some volumetric shrinkage because the aromatic product is more dense than the parent naphthene and because of the decrease in weight due to the loss of six hydrogen atoms.

If pure methylcyclohexane were converted entirely to toluene in a reforming operation, an 83.3 percent volume yield would be obtained and the octane number increase would be 50 units, as pointed out by Kastens and Sutherland.[182]

Haensel and Berger[133] state that the heat of reaction in the conversion of naphthenes to aromatics is endothermic to the extent of about 1000 Btu per pound of naphthenes converted.

Equilibrium data for the dehydrogenation of cyclohexane to benzene have been presented by Fowle, Bent, Ciapetta, Pitts and Leum,[100] as well as by Draeger, Gwin, Leeseman, and Morrow.[79] The equilibrium constant, Kp for the reaction

$$C_6H_{12}\ (\text{cyclohexane}) \rightleftharpoons C_6H_6 + 3H_2$$

$$Kp = \frac{(pH_2)^3\,(pC_6H_6)}{(pC_6H_{12})} = 10^6 \text{ at } 950 \text{ F.}$$

has been discussed by Kirkbride.[188] He points out that this expression indicates that the pressure of hydrogen has a powerful influence on the mole ratio of benzene to cyclohexane in the product.

Figure 2 shows the effect of operating pressure on equilibrium in the dehydrogenation of methylcyclohexane to toluene and Figure 3 shows the effect of added hydrogen on this same reaction.

The dehydrogenation of methylcyclopentane over a chromia-alumina catalyst has been discussed by Heinemann,[151] and benzene production over the Catforming catalyst has been described by Conner, Ciapetta, Leum and Fowle.[66]

It is pointed out by Kirkbride[188] that the conversion of naphthenes to aromatics improves octane rating only for the higher-boiling naphthenes. Thus, methylcyclopentane and cyclohexane have F-1 blending values of 107 and 110, respectively, whereas benzene has an F-1 blending value of 99, so a loss of blending number octane actually occurs in benzene formation. However, the conversion of dimethylcyclohexane to xylene increases the blending octane number from 68 to 145. Thus, prefractionation of catalytic reformer feed should be carried out to give a maximum amount of those materials most susceptible to octane improvement.

Dehydrocyclization of Paraffins—Dehydrocyclization reactions in Platforming have been discussed by Donaldson, Pasik and Haensel.[78] Their studies were made on a hydrogenated Fischer-Tropsch naphtha consisting primarily of *n*-paraffins. Their results indicate that aromatic production by dehydrocyclization of paraffins proceeds readily and is favored by higher temperatures, lower pressures, and lower space velocities. Figure 4 shows a comparison of toluene formation from methylcyclohexane and from normal heptane, showing the lower conversion to toluene obtained with the paraffinic feed as compared to the naphthenic feed. Figure 5 shows the relative effects of various metals and metal oxides in promoting the dehydrocyclization of normal heptane to aromatics plus naphthenes.

Dehydrocyclization reactions involve a substantial volumetric loss due to both density change and production of hydrogen. Further, as pointed out by Grote, Haensel and Sterba,[119] the extent to which dehydrocyclization proceeds in once-through operations is limited by the fact that, as aromatic concentrations increase, the rate of additional dehydrocyclization is drastically reduced.

Hettinger, Keith, Gring and Teter[164] point out that the contribution of dehydrocyclization to over-all hydroforming reactions may be considerable or insignificant, depending on both operating conditions and catalyst employed.

Hydrocracking—Hydrocracking effects in general are the opposite of those associated with dehydrogenation of naphthenes to aromatics. Hydrocracking results in a decrease in density and it absorbs a part of the hydrogen liberated in the dehydrogenation reaction. Also, hydrocracking is exothermic and provides some of the heat of reaction required for dehydrogenation. Hydrocracking also tends to increase the vapor pressure of the gasoline product and the extent of this reaction must be balanced with that of other reforming reactions in order to meet

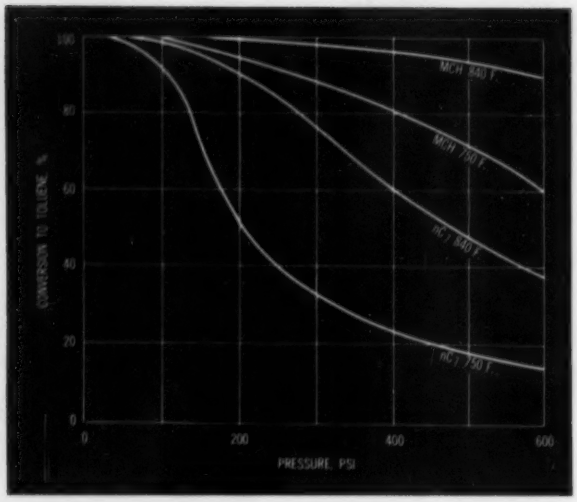


FIGURE 4—MCH conversion compared with Heptane conversion.

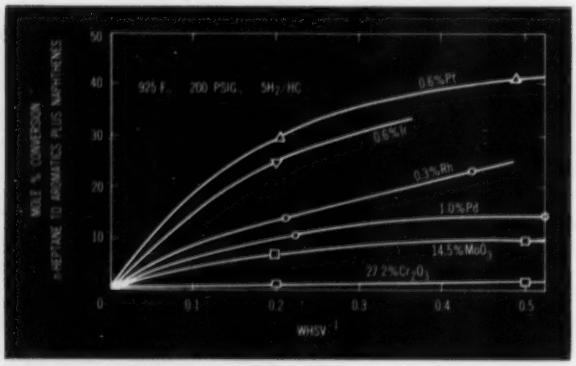


FIGURE 5—Dehydrocyclization activity of catalysts.

product volatility specifications.

Hydrocracking consists of more than one type of reaction. A carbonium-ion type has been discussed by Greensfelder, Vogue and Good[117] and by Haensel and Donaldson.[134] A demethylation type of hydrocracking has been described by Haensel and Ipatieff.[139]

Work on pure compounds, as reported by Haensel and Donaldson[134] has shown that *n*-heptane splits preferentially near the center of the molecule during a Platforming operation. Similarly, the hydrocracking of *n*-heptane and *n*-octane in the presence of the Catforming catalyst gives a minimum amount of methane and ethane and a maximum yield of propane and butane from heptane, and of propane, butane, and pentane from octane, as discussed by Fowle, Bent, Ciapetta, Pitts, and Leum.[100]

Hettinger, Keith, Gring and Teter[164] point out that in going from a C_n equilibrium mixture to a C_{n-1} equilibrium mixture (by hydrocracking, for example), there is an octane improvement of 14-15 units and an accompanying volume loss of some 8-10 percent.

Detailed consideration has been given to the reactions which occur in hydrocracking by Heinemann, Hattman, and Schall[152] in the course of a discussion of the Houdriforming of products from the hydrocracking reactions. Data on the hydrocracking of a number of pure compounds over nickel on silica-alumina catalysts are presented. Hydrocracking of paraffins increased with molecular weight and there was much more tendency to crack isoparaffins than normal paraffins, but the low-molecular weight isoparaffins were more stable than high-molecular weight isoparaffins. Some aromatics and naphthenes are formed in the hydrocracking of paraffins and operating temperature is critical in determining the aromatic to naphthene ratio. In the hydrocracking of naphthenes, ring splitting to give paraffins and dehydrogenating to give aromatics were the predominant conversion reactions; gas yields were very high. Olefins are apparently degraded rapidly and much dry gas is formed in hydrocracking this class of compounds. Hydrocracking of polycyclic aromatics apparently occurs by partial hydrogenation with subsequent splitting of the saturated ring or rings; some of the side chains thus created are split off to give low molecular weight paraffins.

Isomerization—In isomerization in the presence of reforming catalysts, not only are alkylcyclopentanes isomerized to alkylcyclohexanes but paraffin hydrocarbons are isomerized to almost every possible isomer.

Of the three reactions to which paraffin hydrocarbons are subjected in catalytic reforming (isomerization, hydrocracking, and dehydrocyclization), isomerization is the most rapid. However, isomerization is useful only at moderate octane levels because the equilibrium product of the reaction contains substantial quantities of low-octane paraffins, as discussed by Frost,[104] by Livingston[198] and by Rossini.[267] The isomerization of *n*-pentane over a catalyst composed of molybdic oxide on alumina gave about 50 percent isopentane at mole ratios of hydrogen to hydrocarbons greater than three to one, as reported by Clark, Matuszak, Carter and Cromeans.[65]

Figure 6, adapted from an article by Hettinger, Keith,

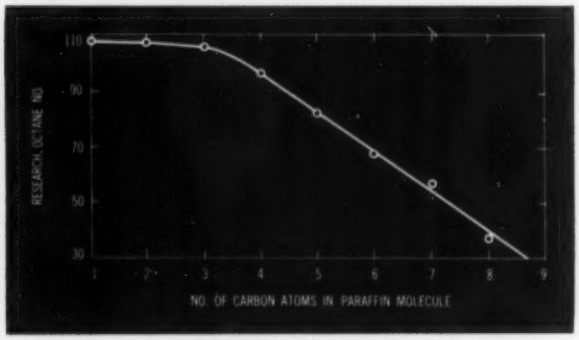


FIGURE 6—R.O.N. of paraffin isomer mixture.

Gring and Teter[164] shows the Research octane number of the various molecular weight paraffin isomers at equilibrium at 900 F. This figure shows that isomerization of C_7 to C_{12} paraffins alone could never meet present-day octane requirements.

The isomerization of alkylcyclopentanes to cyclohexanes is important in order to produce the desired aromatics in the product because about 50 percent of the naphthenes in most naphthas are cyclopentanes, as described by Forziati, Willingham, Mair and Rossini.[98] Equilibrium data for the isomerization of methylcyclopentane to cyclohexane have been presented by Fowle, Bent, Ciapetta, Pitts and Leum.[100] These data are shown

graphically in Figure 7. The equilibrium constant for the reaction

$$C_6H_{12}\ (\text{cyclohexane}) \rightleftharpoons C_6H_{12}\ (\text{methylcyclopentane})$$

$$Kp = \frac{P\ \text{methylcyclopentane}}{P\ \text{cyclohexane}} = 12 \text{ at } 950\ F.$$

has been given by Kirkbride.[188]

Heinemann, Schall, and Stevenson[155] state that the dehydroisomerization of alkylcyclopentanes to aromatics is a relatively slow reaction and that the yields approach equilibrium as the space rate declines. Since the dehydrogenation of naphthenes to aromatics is very rapid, the isomerization of alkylcyclopentanes to cyclohexanes must be the slow, rate-governing step in the over-all dehydroisomerization process.

As pointed out by Heinemann, Mills, Hattman and Kirsch,[153] methylcyclopentane is the most difficult of the naphthenes to convert.

Behavior of Sulfur Compounds

Whereas the sulfur content of a naphtha may only be reduced by 15 percent by thermal reforming, it may be reduced by 97 percent by Platforming, for example, as discussed by Haensel and Sterba.[140]

Sulfur removal in reforming has also been discussed by Kalichevsky and Peters.[181] These authors present data on the relationship of reforming severity to sulfur content of the reformate indicating that sulfur content may drop from 0.04 at a 90 octane (F-1 plus 3cc) number to almost nil at a 100 octane level.

The effect of sulfur compounds on the functioning of Houdriforming catalysts has been reported by Heinemann, Shalit and Briggs.[156]

In catalytic hydro-reforming, desulfurization is accomplished by what might be considered a form of hydrocracking, since cleavage usually occurs between the sulfur and the carbon.

When considering sulfur removal in catalytic reforming operations, one approaches a sort of "twilight zone" between operations which are conducted basically for reforming and those which are conducted basically for desulfurization. Thus, as discussed by Zahnstecher and Petrarca,[326] Autofining (Anglo-Iranian Oil Company) is one such in-between process which produces enough hydrogen for desulfurization by reforming the naphthenes in the feed to aromatics as described by Porter.[250] In contrast to the Autofining type of operation, desulfurization using outside hydrogen may be employed, as typified by Hydrofining, Hydrodesulfurization, and Unifining. Comparative economics for Autofining and for the class of processes using added hydrogen are given by Zahnstecher and Petrarca.[326]

Platreating, a development of Universal Oil Products Company, described by Anon,[5] is a process for treating Platformate prior to Udex extraction when unsaturates may be present and interfere with the Udex operation.

In catalytic reforming over platinum catalysts in the presence of an excess of recycled hydrogen, the sulfur in organic sulfur compounds is generally converted to hydrogen sulfide. It may be desirable to scrub the recycle hydrogen with a chemical absorbent such as diethanolamine to prevent the buildup of hydrogen sulfide in the circulating hydrogen stream. When the feed sulfur content is high enough, sulfur must be removed by feed pretreatment.

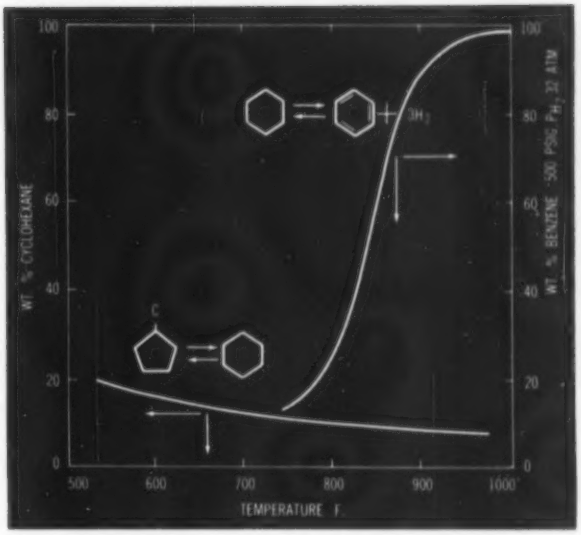


FIGURE 7—Isomerization and dehydrogenation equilibria.

With molybdenum catalysts, the sulfur compounds react with the molybdic oxide in the presence of hydrogen to give molybdenum sulfide. Higher sulfur content feeds can thus be tolerated with molybdenum catalyst, since the sulfur is periodically removed from the molybdenum during regeneration. In fluid hydroforming, the sulfur leaves the regenerator as SO_2. In fixed-bed hydroforming, some leaves the unit as SO_2 during regeneration and some leaves the unit as H_2S during the hydrogen purge period following regeneration.

The Varga effect[305, 306] has to do with the improvement in catalytic dehydrogenation by the presence of a small amount of sulfur in the feed stock by virtue of improved hydroforming catalyst regeneration. A Shell patent by Bannerot[29] sets forth addition of a small quantity of reducible sulfur to the feed stock while also removing H_2S from the recycle gas. Process period was lengthened. A patent by Voorhees[307] claims sulfur removal from a hydrocarbon stock by passage of the stock with a naphthene over a carbon catalyst. Dehydrogenation of the naphthene furnishes the hydrogen for desulfurization.

Catalytic vapor-phase desulfurization in the presence of clay or bauxite has been described by Amero and Wood,[3] by Brooner and Conn[55] and by Martin and Carlson.[204] Such treatment removed mercaptans almost completely and up to 60 percent of the total sulfur in most straight-run gasolines. Such processes involve only low operating and investment costs and result in a small volume loss. At best, however, desulfurization will raise the leaded octane number of the gasoline no more than 6 or 7 points. This increase is a consequence of improved lead susceptibility due to the removal of deleterious sulfur compounds. By increasing time and temperature of such clay treatments, some molecular rearrangement or reforming of the naphtha may be accomplished and addi-

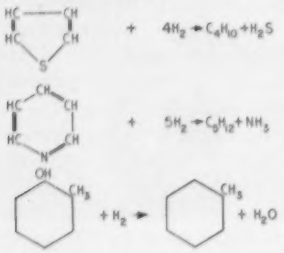
How To Get Those Top Octanes

TABLE 8—Some Basic Relationships in Catalytic Reforming

REACTION INVOLVED	Reaction Rate	Heat Effect	Effect of High Pressure	Effect of High Temps.	Effect of High Space Velocities	Effect on Hydrogen Production	Effect on Product Vapor Pressure	Effect on Product Density	Effect on Volume Yield	Effect on Octane Number
Hydrocracking	Slowest	Quite Exothermic	Aids	Aids	Hinders	Absorbs H_2	Increase	Decrease	Decrease	Increase
Isomerization of Paraffins to iso-paraffins	Rapid	Mildly Exothermic	None	Aids	Hinders	None	Increase	Slight decrease	Slight increase	Increase
Cyclization	Slow	Mildly Exothermic	Hinders	Aids	Hinders	Evolves H_2	Decrease	Increase	Decrease	Increase
Naphthene isomerization	Rapid	Mildly Exothermic (76 Btu. per lb. naphthenes converted)	None	Aids	Hinders	None	Decrease	Slight increase	Slight decrease	Slight decrease
Naphthene dehydrogenation	Very fast	Quite Endothermic (1000 Btu. per lb. naphthenes converted)	Hinders	Aids	Hinders (Effect not marked since reaction rapid)	Evolves H_2	Decrease	Increase	Decrease	Increase (Particularly in case of heavier naphthenes)

tional octane improvement realized, as described by Helmers and Brooner.[157] Such an operation causes a rapid loss in catalyst activity, however, and regeneration equipment must be provided.

Effects of Catalysts—The reactions which occur in catalytic reforming are to a considerable extent a function of the specific catalyst employed. Thus, in the presence of cobalt molybdate; organic sulfur, nitrogen, and oxygen compounds are converted to saturated hydrocarbons and inorganic by-products.



These are in addition to the dehydrogenation of naphthenes, the dehydrocyclization of paraffins to aromatics, and the hydrogenation of olefins, according to Berg.[37]

Kirkbride[188] states that the dual functional catalysts developed for Houdriforming are very selective for:

1. Dehydrogenation of C_6 naphthenes
2. Dehydroisomerization of alkylcyclopentanes
3. Isomerization of normal and slightly-branched paraffins into highly-branched paraffins

Data are presented on two variations of the Houdriforming catalyst—one which has only a dehydrogenation function and one which has both dehydrogenation and isomerization functions.

The halogen incorporated in some platinum catalysts has a specific directing effect on hydrocarbon reactions. Thus, hydrocracking and isomerization are selectively accelerated by the halogen in Platforming catalyst.

Table 8 summarizes some of the relationships between the various reactions in catalytic reforming, the operating conditions employed, and the characteristics of the products obtained.

Process Variables

The major process variables in Platforming (which are generally applicable to the variety of fixed-bed catalytic reforming reactions conducted under hydrogen pressure) have been outlined by Haensel[123] as: (1) Temperature, (2) Pressure, (3) Space velocity and (4) Hydrogen recycle rate.

To these variables must be added that of catalyst-to-naphtha ratio in the case of moving-bed or fluidized-bed processes. In the case of fixed-bed processes, as pointed out by Smoley and Bowles,[288] the variable corresponding to catalyst-to-naphtha ratio is time on-stream per cycle. Thus, a reduction in on-stream time per cycle has the same effect on a fixed-bed unit as an increase in catalyst-to-oil ratio on a continuous catalytic unit. Either one increases the reforming effect as a result of higher average catalyst activity with less carbon deposit per unit of catalyst used.

An increase in temperature gives rise to an increase in both the aromatization and hydrocracking reactions. Both of these reactions contribute materially to increased octane number. It should be emphasized here that catalytic reforming is primarily a catalytic reaction with few undesired thermal reactions.

Low pressure operation favors aromatization and decreases hydrocracking. Operation at 900 psi causes about twice as much hydrocracking as does operation at 500 psi, according to Haensel.[123] Thus, by simply lowering operating pressure, Platforming can be made to produce a highly aromatic, low-volatility gasoline and a lot of hydrogen. Alternatively, high pressure operation will produce a more volatile product with lower aromatic content and less concurrent hydrogen production. The upper limit on operating pressure is set by increasing thermal reactions which adversely affect the yield-octane relationship. The lower limit on operating pressure is set by the minimum amount of hydrocracking desired but mainly by the possibility of carbonizing the catalyst due to insufficient hydrogen pressure.

Kirkbride[188] cites equilibrium data for the reforming of an East Texas naphtha which illustrates the effect of pressure. At the same mole ratio of hydrogen to oil (4:1), operation above 300 psi caused the equilibrium amount of benzene to fall off rapidly while cyclohexane and cyclopentanes increase at the same time. On the other hand, the equilibrium concentration of toluene remains high, even at high pressures.

Forrester, Conn, and Malloy[97] delineate the effects of variation in pressure on catalytic (platinum) reforming. These authors point out that lower pressures give higher gasoline yields, higher octane products from a given naphtha charge, better yields of hydrogen. Lower pressures do, however, contribute to coking and resultant

rapid catalyst deactivation, necessitating an efficient and economic catalyst regeneration scheme.

Low space velocities favor hydrocracking since it is a relatively slow reaction. On the other hand, low space velocities have little effect on dehydrogenation of naphthenes to aromatics since that reaction is relatively rapid.

As pointed out by McGrath,[213] there is a thermal reforming effect prior to introduction of the charge to the catalyst bed. McGrath calls this the "soaking volume factor" and it assumes increased importance as reforming becomes more severe. Reforming severity is most commonly controlled by changing temperature and/or charge rate according to Heinemann, Schall, and Stevenson.[155]

Catalysts

The important characteristics of a reforming catalyst have been listed by Fowle, Bent, Milner, and Masologites[102] as follows:

1. Selectivity—the ability of a catalyst to promote the desired dehydrogenation and isomerization reactions, while controlling cracking.
2. Stability—the maintenance of the desired yield-octane relationship over an extended life.
3. Stamina—the ability to perform satisfactorily under varied refinery operating conditions.

As pointed out by Sachanen,[272] catalysts may be classified according to their effects on paraffin hydrocarbons as follows:

1. Catalysts which weaken C — C and C — H bonds and cause complete decomposition into carbon, hydrogen, and methane. These include platinum, nickel and copper.
2. Catalysts which weaken C — C and particularly C — H bonds and produce a series of decomposition and condensation products. Aluminum chloride is the outstanding example of this class which includes $FeCl_3$ and $ZnCl_2$.
3. Catalysts which weaken C — H bonds and which convert paraffins to olefins and hydrogen. Carbon, alumina and chromic oxide belong to this class.
4. Catalysts which weaken C — C bonds and form olefins and paraffins of a lower number of carbon atoms. These materials are not too selective and may catalyze dehydrogenation reactions also. Oxides and sulfides of molybdenum, vanadium and tungsten are in this class.
5. Catalysts which weaken C — C and C — H bonds and mildly accelerate all cracking reactions. Activated clays and other adsorptive materials fall in this class.

To these might be added a class described by Steiner:[290]

6. Catalyst which dehydrocyclize paraffins to aromatics. Oxides of the fourth, fifth and sixth subgroups of the Periodic Table are in general the only known materials which effect this transformation. Cerium oxide, molybdenum sulfide, and platinum are specific exceptions and *do* catalyze dehydrocyclization.

Interestingly, Steiner[290] points out that the various basic reactions occurring in catalytic reforming all occupy essentially the same active catalyst sites.

Askey, Dedman, and Smalling[28] point out a relationship between activity and surface area for molybdena-alumina hydrofining catalysts. While a fresh catalyst may have a surface of 140 square meters per gram, no appreciable change in activity is noted as long as surface area is above 80 square meters per gram. At 70 square meters per gram (corresponding to an average catalyst life of 11 months), there is a sharp decrease in activity, below which operation is no longer economic. A size-density separation technique permits recovery of reusable catalyst, as described by Askey, Dedman, and Smalling.[28]

In the 1930's there was much interest in finding a catalyst which would permit aromatization at temperatures much below those needed for thermal reforming. It was reasoned that oxide-type catalysts such as molybdenum oxide and chromia which were known to catalyze hydrogenations and dehydrogenations might be effective. Chromia supported on alumina showed superior results at atmospheric pressure for conversion of *n*-heptane to toluene. Molybdena on alumina also proved efficient. The catalyst deactivated quickly due to carbon deposition, however, and to make the process practical, it was necessary to recycle hydrogen to provide a substantial hydrogen partial pressure. As pointed out by McGrath and Hill,[216] the first commercial trials of the molybedena-alumina catalyst were very disappointing, however. Catalyst life was less than three months. Subsequent investigation showed that this rapid deterioration was due to the presence of a few tenths of one percent of sodium in the alumina support. Improved preparation techniques have resulted in lowered sodium content and have extended catalyst life to 9 to 12 months. Now, commercial life may be well in excess of a year.

Molybdenum-Base Catalysts—It has been pointed out by Danziger[70] that the activity and selectivity of molybdenum catalysts can often be significantly improved by changes in one or more of the following variables: (1) Molybdenum compound used, (2) Oxidation state, (3) Support, (4) Promoter, (5) Composition, and (6) Method of manufacture. Danziger goes on to point out that molybdenum oxide is the compound that has received most attention as a reforming catalyst.

As regards oxidation states, molybdenum hydroforming catalysts are alternately oxidized and reduced in operation as described by Gaylor.[108] The reactions are:

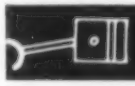
$$MoO_3 + H_2 \rightarrow MoO_2 + H_2O \quad (1)$$
$$MoO_2 + \tfrac{1}{2}O_2 \rightarrow MoO_3 \quad (2)$$

with Reaction (1) occurring during the hydrogen purge period just prior to each reaction period and with Reaction (2) occurring during regeneration.

The kinetics of the reaction $MoO_3 + H_2 \rightarrow MoO_2 + H_2O$ as carried out in a fluidized bed have been studied by Dunoyer.[83] The activation energy for this reaction was determined as 48 kcal per mole.

The virtues of cyclic hydrogen treatment of molybdena-alumina catalysts are explained by Munday and Nicholson.[224] As outlined by Hartley,[146] the hydrogen purge in hydroforming is conducted at atmospheric pressure to aid in water removal from the catalyst since water lowers catalyst activity.

The support material used in molybdenum-base hydroforming catalysts is critical in effective catalysts. Thus, Steiner[290] has shown that molybdena and chromia are inactive by themselves, but are active and stable when supported on alumina. More recently, Clark, Matuszak, Carter and Cromeans[65] have shown that both molybdena and alumina are inactive in pentane isomerization but that the use of 10-20 percent molybdena on alumina, with small additions of silica, was quite effective. Dispersions of molybdena on charcoal were also quite inactive, showing that the alumina is not an inert support but plays an active part in catalysis, presumably through supplying the acid conditions for carbonium-ion type reactions.


How To Get Those Top Octanes

Griffith[118] reports the effects of various promoters on hexane decomposition over a molybdena catalyst. As regards catalyst composition, the addition of cobalt has been found particularly effective in aiding desulfurization reactions.

The effect of molybdenum concentration on the heat stability of molybdena-alumina catalysts has been discussed by Russell and Stokes.[269]

The inclusion of calcium oxide in a conventional molybdena-alumina hydroforming catalyst such that the mole ratio of calcium to molybdenum is approximately 1:1, has been suggested by Welty and Holder.[322] The unique features of this particular catalyst composition are that the molybdenum does not undergo oxidation and reduction. This reduces requirements for regeneration air appreciably.

An alumina base reforming catalyst containing silica and zinc oxide in addition to molybdena has been patented by Davidson.[74]

The incorporation of up to 3 percent magnesium oxide in a molybdena-alumina hydroforming catalyst has been specified in a patent by Oblad and Heinemann.[236]

A reforming catalyst composition consisting of 70 percent SiO_2, 0.5 to 2.0 percent MoO_3 and the balance alumina has ben proposed for a high-pressure (1000 psi) hydroforming operation in a patent by Oblad, Milliken, and Heinemann.[237]

The method of manufacture of molybdenum catalysts are important, since, as pointed out by Danziger,[70] manufacturing techniques affect physical characteristics of the catalyst such as (1) surface area, (2) particle size, (3) pore size, and (4) crystal structure, which are, in turn, important in determining catalyst and selectivity. Ammonium molybdate is generally used as the starting point; acid precipitation gives molybdic oxide in active form. Coprecipitation gives both supported and mixed catalysts. However, supported oxide catalysts can also be made by impregnating the carrier with ammonium molybdate and then heating to 400-500 C.

Nahin and Huffman[228] have reported the results of electron microscope studies on molybdenum-base reforming catalysts. Their data indicate that the active states of molybdena-alumina and cobalt-molybdena-alumina are associated with micro-crystals ranging from 50 to 200 Angstrom units in diameter. They further found that activity decreases progressively with crystal growth.

The chemical and physical properties of alumina-molybdena hydroforming catalysts have been discussed in detail by Webb, Smith, Ehrhardt.[310] Comparisons of impregnated and precipitated catalysts are given by these authors as well as by Saegebarth[273] and it is concluded that coprecipitated molybdena-alumina catalysts are superior with regard to activity, coke formation, and stability as compared to catalysts made by impregnating an alumina support with molybdenum.

Ciapetta and Plank[63] have recently reviewed methods for the preparation of molybdenum catalysts.

Iron, nickel, or cobalt molybdate constitute effective reforming catalyst compositions, according to a patent by Rowan.[268]

The preparation of an impregnated cobalt molybdate catalyst has been described by Hendricks.[160]

Cobalt molybdate is the composition employed by Union Oil Company of California in the Hyperforming process. It is stated that this catalyst combines excellent activity with heat stability and abrasion resistance. The cobalt molybdate catalyst has been employed by Union for the desulfurization of high-sulfur stocks as described by Berg, Bradley, Stirton, Fairfield, Leffert and Ballard.[39]

Platinum Catalysts—Platinum has long been known as a catalyst for the hydrogenation of olefins and the dehydrogenation of naphthenes as discussed by Zelinsky,[327] for example. Fowle, Bent, Ciapetta, Pitts and Leum[100] have discussed the evolution of the present-day platinum reforming catalysts. These authors go on to state that the Catforming catalyst, which they developed, started with the discovery of a good isomerization and dehydrogenating agent and proceeded with its modification to suit the needs of a reforming catalyst. The original catalyst was platinum supported on fresh synthetic silica-alumina cracking catalyst. Research showed that decreasing the surface area of the silica-alumina catalyst by a steam deactivation treatment gave a modified catalyst which was still effective in isomerization but which no longer caused undesirable cracking reactions, as described by Ciapetta.[60]

Although most Platforming patents specify halogen content, a platinum-alumina catalyst which may or may not contain halogen is described by Haensel.[131] A platinum or palladium catalyst containing at least one other metal oxide is specified by Haensel and Gerald.[135]

Water decreases the hydrocracking activity of a platinum-halogen-alumina catalyst according to Berger and Haensel.[43,44] On the other hand, halogen compounds tend to increase hydrocracking activity, according to Cox.[68] Addition of water or halogen may thus be used to control the balance among the various reactions promoted by the Platforming catalyst.

The process of catalyst manufacture comprising combination of 0.1 to 8.0 percent halogen with alumina, compositing platinum sulfide with this, and then oxidizing to give an alumina-platinum oxysulfide-halogen catalyst is outlined by Haensel.[126]

The manufacture of alumina spheres as supports for platinum catalysts has been outlined by Hoekstra.[167] Various specific techniques for depositing the platinum on an alumina base have been detailed by Riblett, Burton, and Le Francois,[261] by Heard and Den Herder,[149] by Guyer, Thorn, and Arundale,[122] and by Kearby.[183]

Although regeneration of Platforming catalyst was not recommended by Haensel,[124,125] a method of regeneration was described by him[127] which employed heating to 600-800 F. in the presence of air or oxygen-containing gas.

A platinum or palladium catalyst supported on an alumina-boria support containing 1-15 percent of B_2O_3 may be used in fixed-bed, fluidized-bed or a suspensoid-type process according to Haensel and Gerald.[136]

An amino compound or basic ammonium salt may be used to insure even distribution of platinum over a support material according to Haensel.[128,129]

The relationship between catalyst pellet size and activity for Platforming catalysts is discussed by Haensel,[130] as well as by Hettinger, et al.[164]

The recovery of platinum from platinum-on-alumina reforming catalyst and the reimpregnation of the carrier is described by Appell.[24]

The technique of acid-washing a noble metal-oxide catalyst with acid to remove metallic contaminants is outlined by Appell.[25] Neither the noble metal nor the oxide are attacked, and the purified mass is washed and calcined for re-use.

The reactivation of a platinum-on-alumina catalyst in situ by burning with gas containing a controlled amount of oxygen is described by Blatz and Brandon.[51] Combustion at 700-1100 F. with oxygen controlled at 2 to 6 percent so the platinum is not oxidized is specified for an initial stage, followed by a second stage wherein oxygen content is increased so that the catalyst is made ready for re-use without reduction.

Chromia-Alumina Catalysts—The effect of repeated use and regeneration on a chromia-alumina catalyst has been discussed by Hughes, Stine and Darling.[175] These same authors discuss the utility of a pre-hydration treatment for lessening the possibility of poisoning of chromia-alumina catalysts by sulfur and of deactivation of such catalysts by calcination. Archibald and Greensfelder[26] have discussed carbon formation on chromia-alumina catalysts and have also presented data on the yield decrease in the dehydrogenation of cyclohexane after repeated regenerations. Both Hughes, Stine and Darling[175] and Archibald and Greensfelder[26] have presented data on the effects of hydrogen atmospheres in naphtha reforming reactions over chromia-alumina catalysts. Hanson and Harrison[143] have presented data on the rate of fouling of chromia-alumina catalyst by coke deposition (in butane dehydrogenation).

Patents on preparation of chromia-alumina reforming catalysts include those by Hunter and Kimberlin[177] and by Smith.[287] The addition of fluoride to chromia-alumina catalysts to impart isomerization activity is suggested by Lang and Gutzeit.[190]

The incorporation of 1-30 percent Sb_2O_3 and 0.1 to 5.0 percent of an oxide of Ga, Cd, Th, Zr, or Ir in a chromia-alumina reforming catalyst is covered by Strecker and Stine.[292]

Other Catalyst Compositions—A number of other chemical compositions have been suggested for reforming catalysts, as outlined by Gaylor.[109]

Thus, activated carbon has been suggested for the catalytic reforming of naphthas by Adams and Kimberlin.[1] A fixed-bed operation was visualized and regeneration with steam was contemplated.

An activated carbon catalyst containing 1-10 percent of an alkali metal compound has been specified for naphtha reforming by Sanford and Friedman.[274]

Molybdena-magnesia and chromia-magnesia reforming catalysts may be prepared by a technique described by Kimberlin.[186]

A nickel-silica-alumina catalyst containing 98 percent SiO_2, 1 percent Al_2O_3, and 1 percent Ni constitutes an effective hydroforming catalyst which can be regenerated, according to Kennedy.[185]

A chromia-beryllia-alumina hydroforming catalyst has been patented by Clark.[64]

Shiffler and Claussen[279] have patented a vanadia-alumina reforming catalyst which is operated in the presence of a sulfur-containing compound so that the ratio V/S ranges from 14 to 2.

An alumina-thoria-zinc oxide catalyst has been patented by Friedman.[103] An iron oxide-chromium oxide aromatization catalyst composition is described by Lang, Stover, and Gutzeit.[191] A catalyst for reforming which contains chromium, carbon, nitrogen and oxygen can be prepared by the decomposition of an alkali metal chromicyanide, as described by Drake and Smith.[80]

Catalyst-Testing Techniques—One important aspect of the reforming catalyst problem is the testing and evaluating of reforming catalysts. While test methods for determining the activity of cracking catalysts may not be entirely worked out to the satisfaction of all concerned, a number of good methods have been developed, as reviewed by Ivey and Veltman.[179] In testing reforming catalysts, on the other hand, almost nothing has been published on catalyst testing techniques. The important answers wanted in the testing of reforming catalysts are: (1) catalyst activity, (2) catalyst selectivity, and (3) catalyst life. Some of the well known fixed-bed activity tests have been applied to reforming catalysts with some minor modifications, including provision for addition of hydrogen with the charge. Analysis of the liquid products from bench-scale activity tests indicates catalyst selectivity. Some work has been done on life tests but catalyst regeneration has been found difficult to duplicate in the laboratory.

The Reforming Catalyst Industry—The magnitude of the reforming catalyst industry was estimated by Ray[253] in 1948 to be 1800 tons having a value of $3.2 million. This was in contrast to 38,000 tons of cracking catalysts having a value of $10 million. Of course, in 1948, this figure represented only fixed-bed molybdenum-base hydroforming catalysts. The use of molybdenum has grown to the point where, in 1954, reforming catalysts constitute the largest market for molybdenum chemicals outside of the steel industry, according to Danziger and Kline.[71] Proportionately, however, platinum catalyst consumption is growing at a much greater rate than molybdenum catalyst consumption. The present status of the reforming catalyst industry is summarized in Table 9.

TABLE 9—Status of the Reforming Catalyst Industry—1955 Estimated

PROCESS	Catalyst Producer	Location	
Molybdenum-Base Catalysts:			
Hydroforming	American Cyanamid Co.	Fort Worth, Texas	Total molybdenum catalyst market: 13.8 MM lbs. @ 0.60/lb. = $8.3 MM
Hydroforming	Oronite Chemical Co.	Richmond, Calif.	
Hydroforming	National Aluminate Corp.	Chicago	
Hydroforming	Harshaw Chemical Co.	Cleveland, Ohio	
Hyperforming	Harshaw Chemical Co.	Cleveland, Ohio	
Platinum-Base Catalysts:			**Platinum catalyst** for new construction: 2.5 MM lbs. @ $11.00/lb. = $27.1 MM Recovered platinum catalyst: 5.8 MM lbs. @ $4.00/lb. = $23.4 MM
Platforming	Universal Polychem Co.	McCook, Ill.	
Platforming	Universal Polychem Co.	Shreveport, La.	
Platforming	Universal-Matthey Products, Ltd.	England	
Catforming	Davison Chemical Corp.	Baltimore	
Catforming	Kali Chemie A.G.	Hanover, Germany	
Houdriforming	Houdry Process Co.	Paulsboro, N. J.	
Houdriforming	Chemische Werke Huels	Recklinghausen, Germany	
Ultraforming	American Cyanamid Co.	Willow Island, W. Va.	
Sinclair-Baker	Baker & Co.	Newark, N. J.	
Sovaforming	Baker & Co.	Newark, N.J.	
Esso	Davison Chemical Corp.	Baltimore	
Other Catalysts:			
TCR	Socony Mobil Oil Co.	Paulsboro, N. J.	
Cycloversion	.....	.....	

Molybdenum catalyst consumption is estimated at 13.8 MM lbs. @ 0.60/lb. = $8.3 MM

Platinum catalyst for new construction: 2.5 MM lbs. @ $11.00/lb. = $27.1 MM

Recovered platinum catalyst: 5.8 MM lbs. @ $4.00/lb. = $23.4 MM

How To Get Those Top Octanes

By-Product Hydrogen

As pointed out by Ciapetta,[59] large amounts of hydrogen, ranging from 80 to 95 percent purity, are obtained as by-products of hydrocarbon reforming. Assuming an average production of 500 cubic feet of hydrogen per barrel of straight-run naphtha charged, refineries will be producing 500 million cubic feet of hydrogen per day by the end of 1955. Uses for this hydrogen are as follows:

1. To reduce sulfur, nitrogen, and unsaturation in reformer charge stocks.
2. To reduce sulfur and mercaptan contents and to improve color, storage stability, and combustion characteristics of light distillate fuel oil.
3. To reduce sulfur and carbon residue and to improve color, odor, and stability of lube oils.
4. In the manufacture of petrochemical ammonia. According to Ciapetta, 11 percent of the ammonia produced in the U. S. by the end of 1955 will utilize hydrogen from catalytic reforming.

An excellent review of the present status of various hydrotreating processes has been presented by Weber.[312]

The purity of the hydrogen from a particular reforming process may affect its possible utilization in other processing. Thus, as shown in Table 4, the molybdenum catalyst processes produce hydrogen of 60-70 percent purity and the platinum catalyst processes produce hydrogen of 80-95 percent purity. Where dehydrogenation predominates in reforming, purer hydrogen will be produced; where hydrocracking occurs to a larger extent, the hydrogen will contain increasing amounts of light hydrocarbons.

Net hydrogen made is a function of the charge stock and of the severity of the reforming operation, and is not affected by the recycle hydrogen rate within the unit. Of course, the hydrogen recycle rate is of the order of ten times the net hydrogen made.

Recycle hydrogen may have to be passed through a chemical absorber to prevent excessive buildup of H_2S where high-sulfur stocks are being charged to a reforming unit. Available H_2S-absorption processes have been reviewed by Kohl.[189] Depending on the tolerance of the reforming catalyst for water, an aqueous H_2S scrubber may have to be followed by a dehydrating column.

With the widespread adoption of catalytic reforming by refiners, it has become increasingly important to develop means for handling marginal feed stocks, which, due to their sulfur, nitrogen, olefin, or metals contents would be unsuitable for catalytic reforming over platinum catalysts. An obvious solution to this problem of reformer feed preparation would seem to be to utilize the excess hydrogen available as a reforming by-product in a feed preparation step, as outlined by Stevenson and Mills.[291]

Processes using outside hydrogen (possibly reformer off gas) are available for desulfurization and feed pretreatment. These include:

- Hydrofining, licensed by Esso Research and Engineering Company, and described by Patterson and Jones.[242] A similar Standard Oil Company (Indiana) development is described by Zimmerschied, Hunt, and Wilson.[329]
- Hydrodesulfurization, licensed by Shell Development Company and described by Hoog, Klinkert and Schaafsma.[171]
- HDS (hydrodesulfurization), licensed by Gulf Research & Development Company and described by McAfee, Montgomery, Hirsch, Horne and Summers.[210]
- Unifining, licensed by Universal Oil Products Company and Union Oil Company of California and described by Grote, Watkins, Poll, and Hendricks.[120] This is the process originally designated Hydrobon by UOP (who still retain that name for the catalyst they make for Unifining installations).

Some details of processing and comparative economics involved in the manufacture of ammonia from various hydrogen sources (including reformer gas) have been presented by Updegraff and Mayland,[304] by Duff[81] and also by Pfeiffer and Sandler.[247]

Aromatics Recovery

Since catalytic reforming produces substantial quantities of aromatics, and since chemicals manufacture is constantly increasing its demands for benzene, toluene and xylene, aromatics recovery from reformates is of obvious importance as discussed by Bramston-Cook.[54] However, petrochemicals manufacture is outside the scope of this paper.

Aromatics separation and recycling of the paraffinic fraction to some type of reforming operation does constitute an important adjunct to present-day catalytic reforming operations.

The principal methods employed for aromatics recovery are adsorption followed by fractional desorption (the Arosorb process) as described by Davis, Harper and Weatherly,[75] solvent extraction (the Udex process) as described by Read[258] and sulfur-dioxide extraction as described by Marshall,[203] extractive distillation (the Shell process) as described by Dunn and Liedholm,[82] and azeotropic distillation as described by Hartley.[146] Conventional distillation cannot be employed because boiling point of aromatics and non-aromatics coincide.

Aside from aromatics recovery from the main reformate stream, an additional source of aromatics is the heavy by-product which is separated from the reformate from certain processes and which contains a large proportion of alkylnaphthalenes. As discussed by Anon,[7] condensation of these aromatics with formaldehyde gives high yields of a resin which has shown excellent results in linseed- and tung-oil varnishes.

Thermal Reforming

As pointed out by Murphree,[225] most refiners have used thermal reforming for octane improvement of heavy virgin naphthas. Since the octane numbers of light (C_6 to 200 F.) virgin naphthas are about 65-70 and since heavy (200-400 F.) naphthas run about 30-50 octane, most attention has been given to this heavier fraction.

Thermal reforming is principally concerned with a cracking reaction to produce olefinic compounds of lower molecular weight. Above octane number levels of 90 clear (95 with 2cc TEL), very high yield losses are encountered when one attempts to improve octanes through thermal reforming. This large production of C_3 and C_4 olefins at high severities makes it necessary to complement thermal reforming with catalytic polymerization in order to improve yields and reduce the vapor pressure of the gasoline product.

A flow diagram of a typical commercial thermal reforming plant is shown in Figure 8.

Thermal reforming has been discussed by Sachanen.[272] Operating temperatures are 930 to 1040 F. and operating pressures are 250 to 1000 psi. The most widely used reforming temperature is 1000 F., and the reaction time at

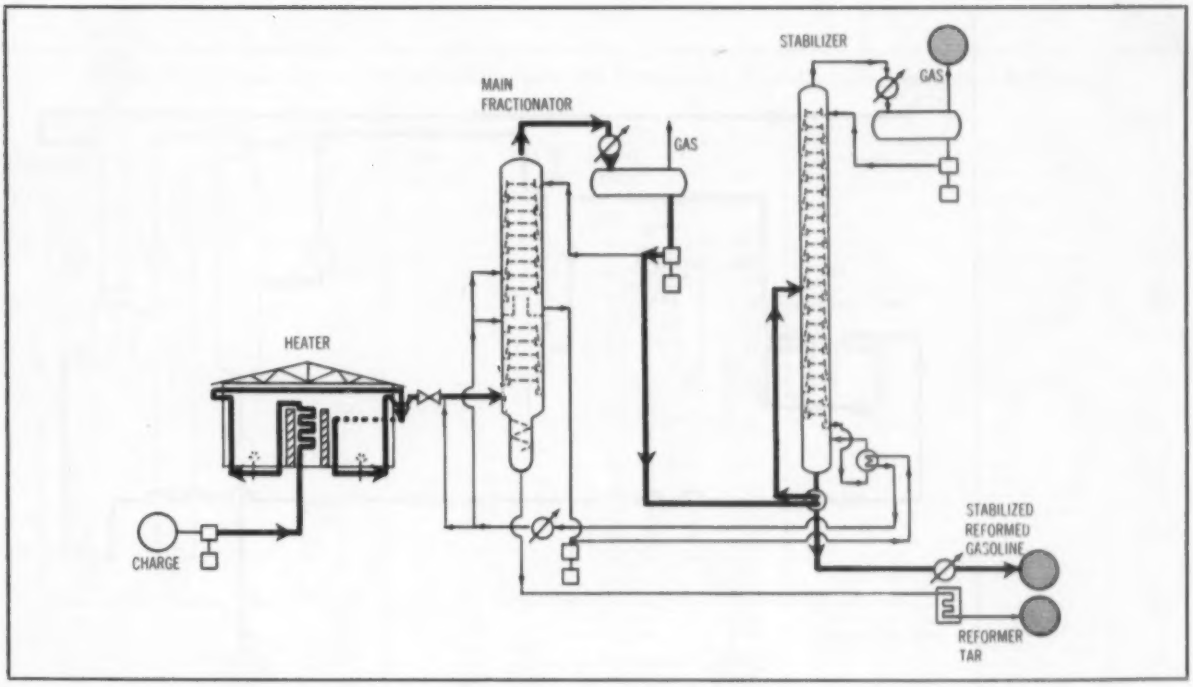


FIGURE 8—Thermal reforming.

that temperature is 10-20 seconds.

As discussed by Haensel and Sterba,[140] thermal reforming was a well-established process in the early 1930's. Features of plants in use at the time have been described by Egloff and Nelson,[87] by Goldtrap,[112] and by Le Roi and Ferguson,[193] and those plants do not differ materially from thermal reforming units in use today.

The feed to thermal reforming units may be prefractionated to remove the higher octane number light ends, before reforming the heavy ends of the naphtha. As the octane number of the final blended product increases, this prefractionation becomes less economical and it becomes more economical to reform the entire naphtha as discussed by Egloff, Nelson and Zimmerman.[88]

The octane number improvement resulting from thermal reforming may be predicted by techniques described by Feuchter,[95] by Gary and Adams,[107] by Tighe,[301] by Turner and Le Roi,[302] and by Anon.[6]

The production of olefins from thermal reforming as feed stocks for alkylation and polymerization processes has been discussed by Egloff.[85] Data on the yield-octane relationship obtained by catalytic polymerization of the propenes and butenes from thermal reforming have been presented by Mase and Turner.[209] Data are presented for each of two naphthas at various reforming severities.

In thermal reforming, coke formation is not a problem and a high conversion-per-pass can be obtained without coke formation. Further, the octane number of the product gasolines are greater in a high-conversion, once-through process, so recycle operation is rarely used in thermal reforming.

Yields of thermally-reformed gasolines vary from 70 to 90 percent when producing a 70-octane product according to Sachanen.[272] The average balance of products in thermal reforming operations is given by Sachanen as follows:

Reformed gasoline, 75 percent; gas, 18 percent; and residuum, 7 percent.

Polyforming

Thermal reforming of low-octane number naphthas can be carried out in the presence of olefinic gases as described by Wagner,[309] by Ruthruff,[279] and by Maschwitz.[206, 207] The reforming reactions are accompanied by thermal polymerization of the olefinic gases. The temperature of this polymerization-reforming operation is the same as that for thermal reforming, 1000 F., but the pressure is higher, ranging from 500 to 3000 psi.

A specific process which is a commercial application of this type of operation is Polyforming as described by Ostergaard and Smoley,[240] by Bogk, Ostergaard and Smoley,[53] by Hirsch, Ostergaard and Offutt,[166] by Offutt, Ostergaard, Fogle, and Beuther,[239] and by Goldtrap and Jones.[113] A variation of Polyforming is the gas reversion process. In Polyforming, the gas and naphtha streams are converted concurrently and in gas reversion the naphtha is introduced after the gas stream has been subjected to a partial conversion.

The yield-octane limitations for this type of processing are about the same as for thermal reforming and polymerization carried out in two separate steps. A flow diagram of the Polyforming process is shown in Figure 9.

An interesting Polyforming variation which has been explored by Berg et al.[41] on a laboratory scale is catalytic Polyforming.

Catalytic Reforming

Catalytic reforming is the fastest growing of all refinery

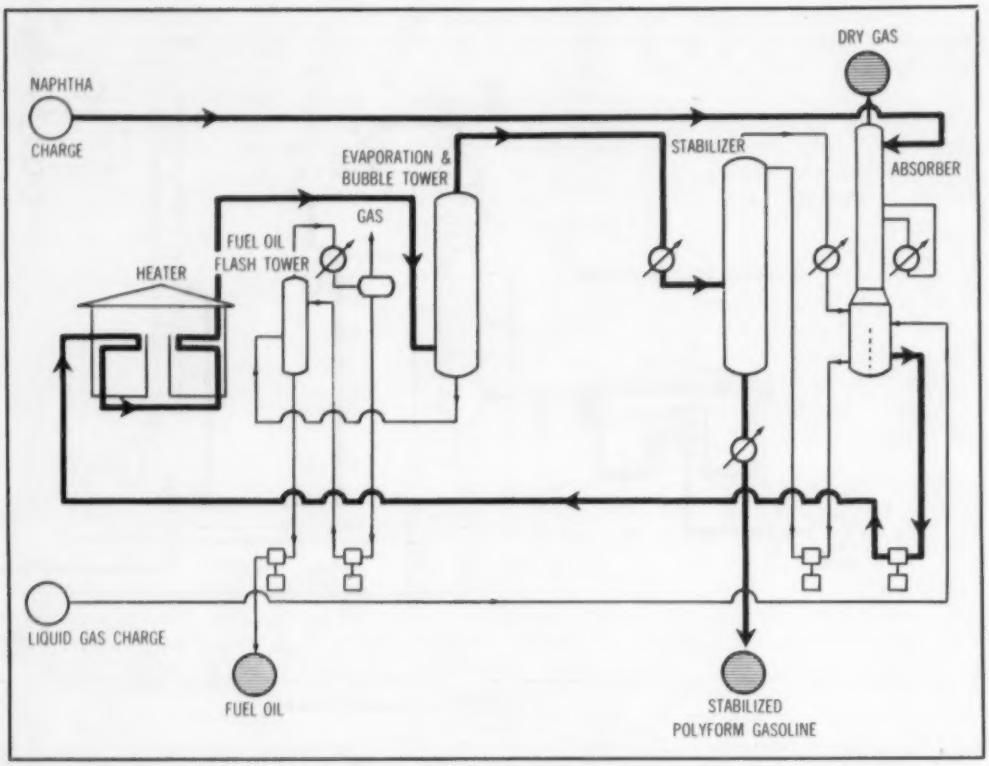


FIGURE 9—Naphtha Polyforming.

processes today. Figure 10 shows the chronology of the development of the various catalytic reforming processes and Table 10 shows the growth in catalytic reforming capacity over the years. Table 11 shows the number, location, and capacities of the catalytic reforming units installed and under construction today.

Figure 11 shows the yield-octane number relationships which can be expected from some of the various types of catalytic reforming processes.

With Moly Catalysts—Fixed-Bed Hydroforming—Fixed-bed hydroforming was the first catalytic naphtha-upgrading process to be applied commercially, as described by Smith and Moore.[286] The first unit was built in 1939 and eight additional plants were built during World War II for production of toluene. One of these plants alone produced more than half of the toluene used for TNT manufacture in that war, according to Hughes.[173]

The place of the hydroforming process in postwar refining was discussed by Anon.[8] The cycle-timer and interconnected control system of a fixed-bed hydroforming unit were discussed by Anon.[9]

Hartley[146] has discussed the commercial synthesis of toluene by hydroforming as well as toluene recovery by azeotropic distillation. Detailed data are presented on the fixed-bed hydroforming unit at the Oleum, Calif., refinery of Union Oil Company of California. Operation

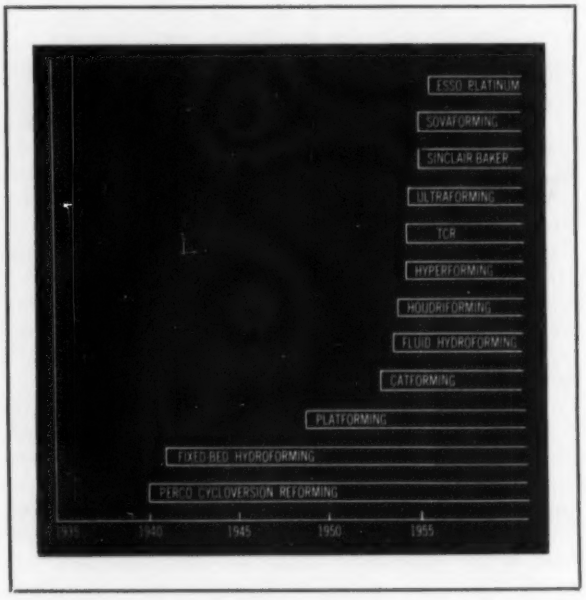


FIGURE 10—Chronology of the development of catalytic reforming processes.

TABLE 10—The Growth in U. S. Catalytic Reforming Capacity

YEAR	M Bbls/Day	YEAR	M Bbls/Day
1951	125	1954	600
1952	194	1955	1040
1953	249	1960 (Est.)	1750

of a fixed-bed hydroformer in an Argentine refinery is discussed by Swift, Stiles, Howard and Tarnpoll.[296] A presentation of data on fixed-bed hydroforming and a comparison with thermal reforming has been made by McGrath and Hill.[216] Constructional details of a fixed-bed hydroformer have been published by Hill, Vincent, and Everett.[165] Details of internal insulation for vessels

TABLE 11—Summary of World-Wide Catalytic Reforming Installations (Built and Building)

Company	Location	Capacity bpd
Fixed-bed molybdenum hydroforming:		
American Oil Co.	Texas City, Texas	7,500
Pure Oil Co.	Toledo, Ohio	5,000
Std. Oil Co. of Calif.	Richmond, Calif.	13,800
Std. Oil Co. (Ind.)	Whiting, Ind.	14,000
Texas Co.	Lockport, Ill.	9,000
TOTAL CAPACITY (5 Units)		49,300
Fluid Hydroforming:		
Arabian Amer. Oil Co.	Ras Tanura, Saudi Arabia	12,500
Cities Service Oil Co.	East Chicago, Ind.	13,000
Cities Service Oil Co.	Lake Charles, La.	17,250
Creole Petr. Corp.	Amuay, Venezuela	11,000
Esso A.G.	Hamburg, Germany	7,800
Esso Petr. Co.	Fawley, England	15,000
Esso Std. Oil Co.	Baton Rouge, La.	22,000
Pan-Am Southern	Destrehan, La.	2,000
Std. Oil Co. (Ind.)	Whiting, Ind.	30,000
Stonic Industria Petrolifera	Livorno, Italy	8,800
Toa Nenryo Kogyo Co. Ltd.	Wakayama, Japan	4,700
TOTAL CAPACITY (11 Units)		144,050
Hyperforming:		
Calstate Ref. Co.	Signal Hill, Calif.	1,100
Platforming:		
Atlas Processing Co.	Shreveport, La.	5,000
Aurora Gasoline Co.	Detroit, Mich.	4,500
Aurora Gasoline Co.	Elsi, Mich.	1,500
Aurora Gasoline Co.	Muskegon, Mich.	2,400
Bell Oil & Gas Corp.	Grandfield, Okla.	1,800
Bitumen Oil & Ref., Ltd.	Matraville, N.S.W., Austr.	1,500
British Petroleum Co.	Kwinana, Australia	6,000
British Petroleum Co.	Kent, England	6,000
British Petrcleum Co.	Llandarcy, Wales	6,000
British Petroleum Co.	Aden, Arabia	12,000
California Oil Co.	Barber, N. J.	10,000
Canadian Oil Ref., Ltd.	Corunna, Ontario	4,000
Century Refining Co.	Shallow Water, Kas.	1,000
C.E.P.S.A.	Santa Cruz, Tenerife	5,500
Champlin Refining Co.	Enid, Okla.	5,000
Clark Refining Co.	Blue Island, Ill.	5,500
Col-Tex Refining Co.	Colorado City, Texas	1,500
Continental Oil Co.	Ponca City, Okla.	5,000
Cosden Petr. Corp.	Big Spring, Texas	4,500
Danaho Ref. Co.	Pettus, Texas	1,000
D. P. Benzin und Petr. GMBH	Hamburg, Germany	6,000
Eastern States Petr. Co.	Houston	7,000
Elk Refining Co.	Falling Rock, W. Va.	1,500
Famariss Oil & Ref. Co.	Hobbs, N. M.	600
Famariss Oil & Ref. Co.	Monument, N. M.	650
Frontier Ref. Co.	Cheyenne, Wyo.	2,000
Gelsenberg Benzin A.G.	Gelsenkirche, Germany	7,500
Great Southern Chem. Co.	Corpus Christi, Texas	4,000
Gulf Oil Corp.	Philadelphia	16,000
Gulf Oil Corp.	Port Arthur, Texas	30,000
Gulf Oil Corp.	Cincinnati, Ohio	10,000
Gulf Oil Corp.	Toledo, Ohio	10,000
Illinois Farm Supply Co.	Pana, Ill.	600
Johnson Oil & Ref. Co.	Cleveland, Okla.	1,800
Kendall Refining Co.	Bradford, Pa.	1,500
Koa Oil Co., Ltd.	Maifu, Japan	1,200
Lake Superior Ref. Co.	Superior, Wisc.	1,000
McColl-Frontenac Oil Co.	Montreal, Quebec	12,000
McMurrey Ref. Co.	Tyler, Texas	5,000
McNutt Oil & Ref. Co.	Brickland, N. M.	650
Mediterranean Ref. Co.	Sidon, Lebanon	650
Mid-West Refineries, Inc.	Alma, Mich.	2,000
Mitsubishi Oil Co.	Kawasaki, Japan	1,600
Mohawk Petroleum Co.	Bakersfield, Calif.	2,500
Naph-Sol Refining Co.	Muskegon, Mich.	1,000
National Oil Refining Co.	Llandarcy, Wales	6,000
Nippon Petr. Ref. Co.	Kudamatsu, Japan	1,500
Onyx Refining Co.	Abilene, Texas	750
Petroleum Specialties, Inc.	Flat Rock, Mich.	1,000
Phillips Petroleum Co.	Sweeny, Texas	16,000
Phillips Petroleum Co.	Phillips, Texas	16,000
Pontiac Refining Corp.	Corpus Christi, Texas	5,800
Premier Oil Ref. Co.	Fort Worth, Texas	1,600
Quaker State Oil & Ref. Co.	St. Marys, W. Va.	900
Quaker State Oil Ref. Co.	Farmers Valley, Pa.	1,500
Quaker State Oil Ref. Co.	Emlenton, Pa.	900
R & J Oil & Ref. Co.	Princeton, Ind.	750
Republic Ref. Co.	Texas City, Texas	5,000
Rock Island Ref. Corp.	Indianapolis, Ind.	1,500
Roosevelt Oil & Ref. Co.	Mt. Pleasant, Mich.	2,000
Rothschild Oil Co.	Santa Fe Springs	1,200
Rothschild Oil Co.	Santa Fe Springs	6,000
S.G.H.P.	Martigues, France	5,500
Shell Deutsche A.G.	Hamburg, Germany	600
Shell Oil Co.	Houston	12,000
Shell Oil Co.	Houston	16,000
Shell Oil Co.	Wood River, Ill.	4,500
Shell Oil Co.	Martines, Calif.	4,500
Shell Oil Co.	Wood River, Ill.	16,000
Shell Oil Co.	Wilmington, Calif.	4,000
Shell Oil Co.	Anacortes, Wash.	8,000
Shell Refining & Mkt. Co.	Shell Haven, England	6,000
Shell Refining & Mkt. Co.	Stanlow, England	7,000
Showa Oil Co.	Kawasaki, Japan	1,750
Skelly Oil Co.	Longview, Texas	2,000
Skelly Oil Co.	El Dorado, Kan.	7,500
Std. Oil Co. of Calif.	El Segundo, Calif.	11,000
Std. Oil Co. of Calif.	El Segundo, Calif.	20,000
Std. Oil Co. of Calif.	Richmond, Calif.	20,000
Std. Oil Co. of Ohio	Lima, Ohio	12,000
Std. Oil Co. of Texas	El Paso, Texas	4,300
Sun Oil Co.	Toledo, Ohio	15,000
Sunray Oil Co.	Duncan, Okla.	5,000
Tankage & Transport Co.	Antwerp, Belgium	650
Taylor Oil & Gas Co.	Port Isabel, Texas	4,000
Taylor Oil & Gas Co.	Corpus Christi, Texas	5,000
Texas Co.	Amarillo, Texas	5,000
Texas Co.	El Paso	4,000
Texas Co.	Port Arthur, Texas	20,000
Texas Co.	Lawrenceville, Ill.	12,000
Texas Co.	Lockport, Ill.	11,000
Texas Co.	Westville, N. J.	12,000
Texas Co.	Wilmington, Calif.	10,000
Tidewater Assoc. Oil Co.	Avon, Calif.	10,000
Trinidad Leaseholds	Port Credit, Ont.	2,000
Union Oil Co.	Oleum, Calif.	15,000
Wilcox Oil Co.	Bristow, Okla.	1,600
Continental Oil Co.	Westlake, La.	5,600
TOTAL CAPACITY (98 Units)		599,750
Catforming:		
Anderson-Prichard Oil Corp.	Cyril, Okla.	1,000
Anglo-Amer. Exploration, Ltd.	Hartell, Alberta	1,000
Atlantic Refining Co.	Philadelphia, Pa.	15,000
Atlantic Refining Co.	Port Arthur, Texas	8,000
British-American Oil Co.	Calgary, Alberta	2,000
British-American Oil Co.	Montreal, Quebec	13,000
Canal Refining Co.	Church Point, La.	750
Chinese Petroleum Co.	Kaohsiung, Formosa	2,500
Douglas Oil Co.	Bakersfield, Calif.	2,500
DX-Sunray Oil Co.	Tulsa	7,500
Gladewater Refining Co.	Gladewater, Texas	750
Greek Government Refinery	Athens, Greece	8,300
Husky Oil & Refining Co., Ltd.	Cody, Wyo.	1,000
Husky Oil & Refining Co., Ltd.	Ft. Williams, Ontario	1,000
Husky Oil & Refining Co., Ltd.	Moose Jaw, Saskatchewan	1,000
I.L.S.E.A.	Valmadrera, Italy	500
Italia S.p.A.	Cremona, Italy	800
Koppartrans Oljeaktiebolag	Gothenburg, Sweden	5,000
Malco Refineries, Inc.	Prewitt, N. M.	750
McBride Oil & Gas Corp.	La Blanca, Texas	750
Neste Oy	Helsinki, Finland	3,500
North American Petroleum Corp.	Corpus Christi, Texas	2,500
Union Oil Co. of Calif.	Cut Bank, Montana	600
United Refining Co.	Warren, Pa.	2,500
Williston Basin Ref. Co.	Williston, N.D.	300
TOTAL CAPACITY (25 Units)		82,400
Houdriforming:		
Ashland Oil & Ref. Co.	Catlettsburg, Ky.	6,000
Commonwealth Ref. Co.	Puerto Rico	3,730
Crown Central Petr. Corp.	Pasadena, Texas	5,000
Gewerkschaft Erdol Raffinerie	Emsland, Germany	3,500
Ohio Oil Co.	Robinson, Ill.	8,330
Petrocarbon Chem. Co.	Irving, Texas	1,000
Sun Oil Co.	Marcus Hook, Pa.	15,000
Sun Oil Co.	Marcus Hook, Pa.	18,000
Sun Oil Co.	Sarnia, Ontario	3,000
Western States Ref. Co.	No. Salt Lake City, Utah	1,000
X-L Refineries	Dawson Creek, Canada	500
TOTAL CAPACITY (11 Units)		65,060
Esso Platinum:		
Carter Oil Co.	Billings, Mont.	2,500
Esso Standard	Baltimore	3,000
Imperial Oil Co., Ltd.	Edmonton, Alberta	2,000
Imperial Oil Co., Ltd.	Sarnia, Ontario	15,000
TOTAL CAPACITY (4 Units)		22,500
Sovaforming (Employing Sinclair-Baker RD-150 catalyst)		
General Petr. Corp.	Ferndale, Wash.	5,400
General Petr. Corp.	Ferndale, Wash.	.....
General Petr. Corp.	Torrance, Calif.	.....
Magnolia Petr. Co.	Beaumont, Texas	.....
Socony-Mobil Oil Co.	Augusta, Kan.	2,700
Socony-Mobil Oil Co.	Augusta, Kan.	.....
Socony-Mobil Oil Co.	Brooklyn, N. Y.	.....
Socony-Mobil Oil Co.	Buffalo, N. Y.	.....
Socony-Mobil Oil Co.	Casper, Wyo.	.....
Socony-Mobil Oil Co.	East Chicago, Ind.	8,000
Socony-Mobil Oil Co.	East St. Louis, Ill.	.....
Socony-Mobil Oil Co.	Paulsboro, N. J.	18,000
Socony-Mobil Oil Co.	Trenton, Mich.	8,000
TOTAL CAPACITY (13 Units)		111,100
Ultraforming:		
American Oil Co.	Texas City, Texas	21,200
American Oil Co.	Yorktwon, Va.	6,000
Canadian Petrofina	Montreal, Quebec	3,600
Derby Refining Co.	Wichita, Kas.	2,500
Great Northern Oil Corp.	St. Paul, Minn.	5,000
Humble Oil & Ref. Co.	Baytown, Texas	20,000
Humble Oil & Ref. Co.	Baytown, Texas	20,000
Leonard Refining Co.	Alma, Mich.	2,500
Pan-Am Southern	Eldorado, Ark.	6,200
Pure Oil Co.	Smiths Bluffs, Texas	15,000
Std. Oil Co. (Ind.)	Casper, Wyo.	3,700
Std. Oil Co. (Ind.)	Mandan, N. D.	6,000
Std. Oil Co. (Ind.)	Sugar Creek, Mo.	14,000
Std. Oil Co. (Ind.)	Wood River, Ill.	9,000
Std. Oil Co. (Ohio)	Cleveland, Ohio	11,000
Utah Oil Co.	Salt Lake City, Utah	5,500
TOTAL CAPACITY (16 Units)		151,200
Sinclair-Baker:		
Pure Oil Co.	Newark, Ohio	3,000
Richfield Oil Co.	Watson, Calif.	17,000
Sinclair Ref. Co.	East Chicago, Ind.	16,000
Sinclair Ref. Co.	Houston	24,000
Sinclair Ref. Co.	Marcus Hook, Pa.	16,000
TOTAL CAPACITY (5 Units)		76,000
TCR:		
General Petroleum Co.	Torrance, Calif.	17,000
Magnolia Petroleum Co.	Beaumont, Texas	17,000
TOTAL CAPACITY (2 Units)		34,000
Cycloversion:		
Anderson-Prichard Oil Co.	Arkansas City, Kas.	4,000
Evangeline Ref. Co.	Jennings, La.	450
Lakeside Ref. Co.	Kalamazoo, Mich.	1,000
M.F.A. Oil Co.	Chanute, Ill.	1,000
Sinclair Ref. Co.	Wood River, Ill.	6,000
Southwestern Oil & Ref. Co.	Corpus Christi, Texas	5,000
Wisconsin Oil Ref. Co.	Sheboygan, Wis.	1,600
TOTAL CAPACITY (7 Units)		19,050
GRAND TOTAL CAPACITY (194 Units)		1,355,510

How To Get Those Top Octanes

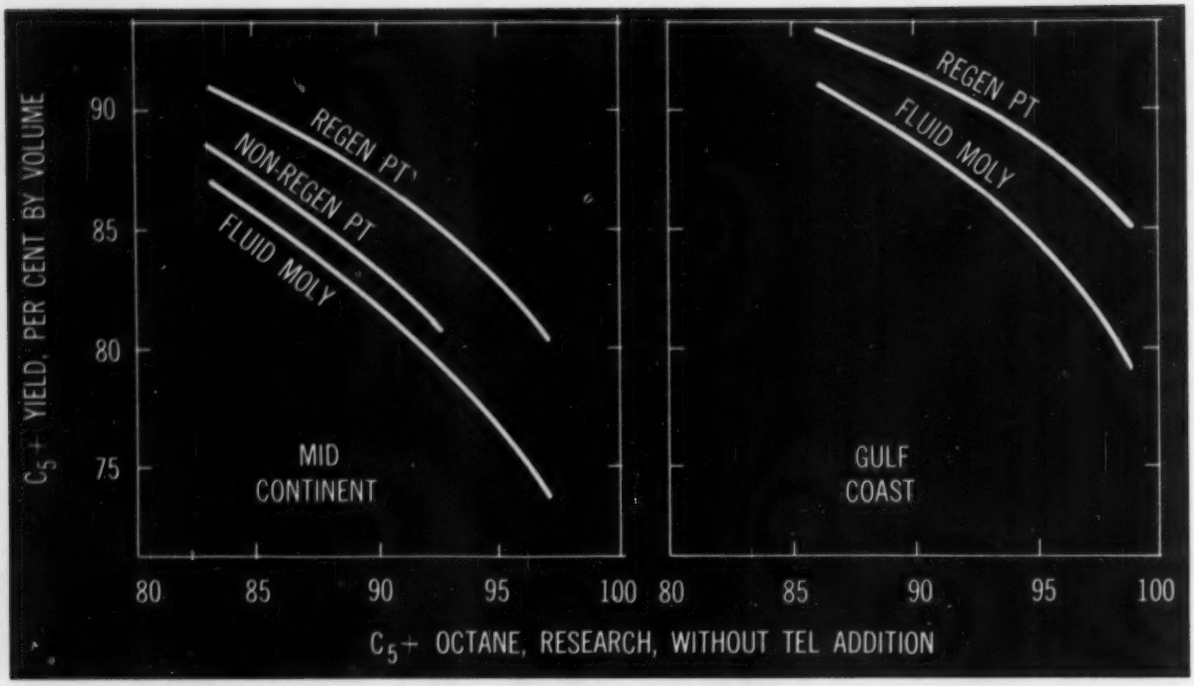


FIGURE 11—Yield-octane comparison for reforming processes.

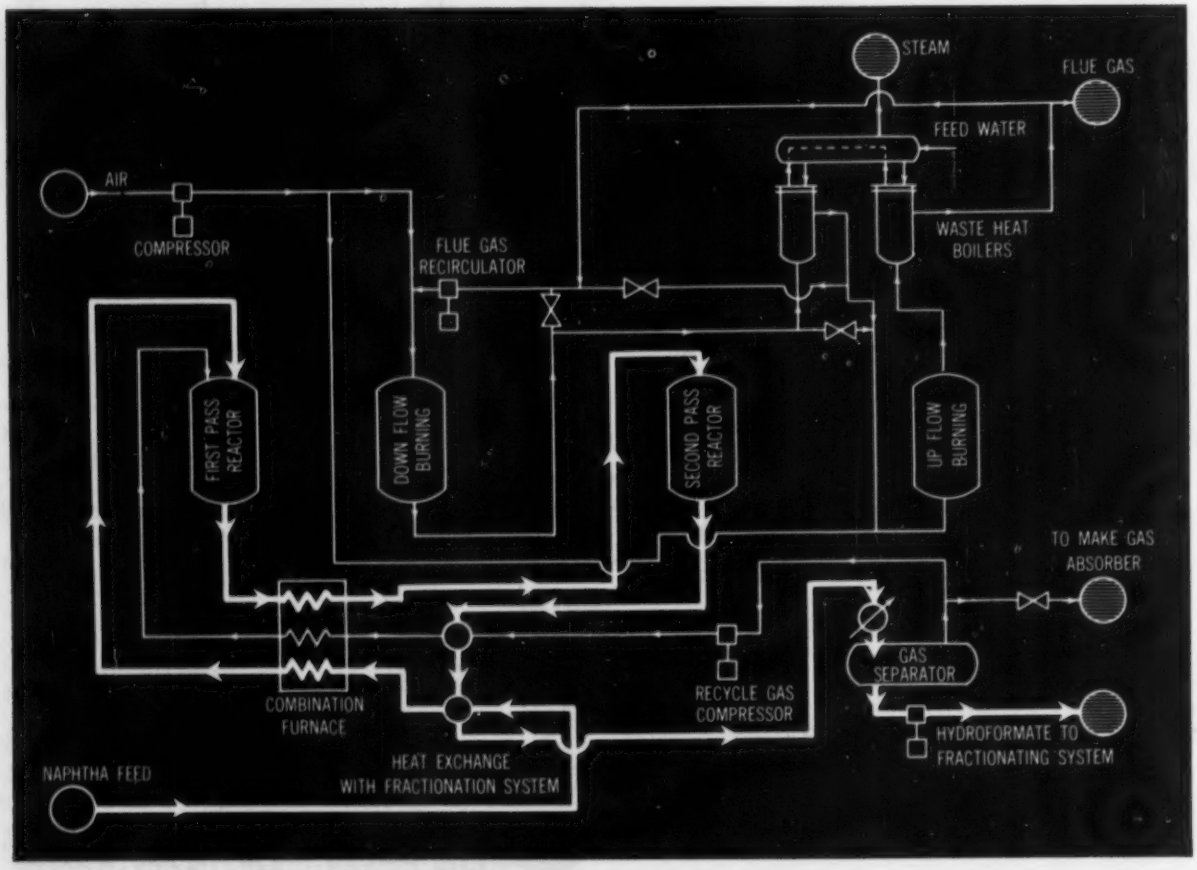


FIGURE 12—Fixed-bed hydroforming.

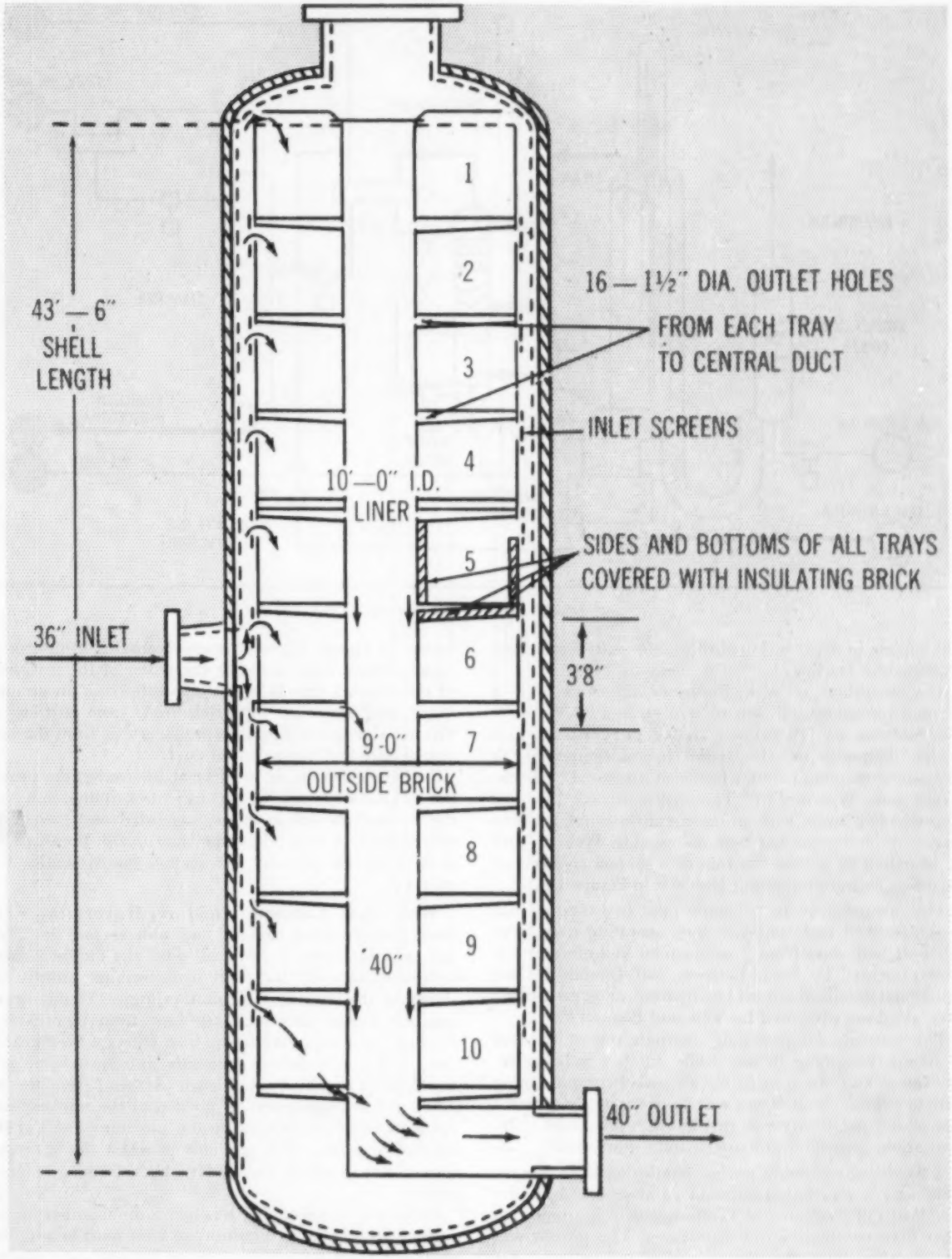


FIGURE 13—Reforming reactor.

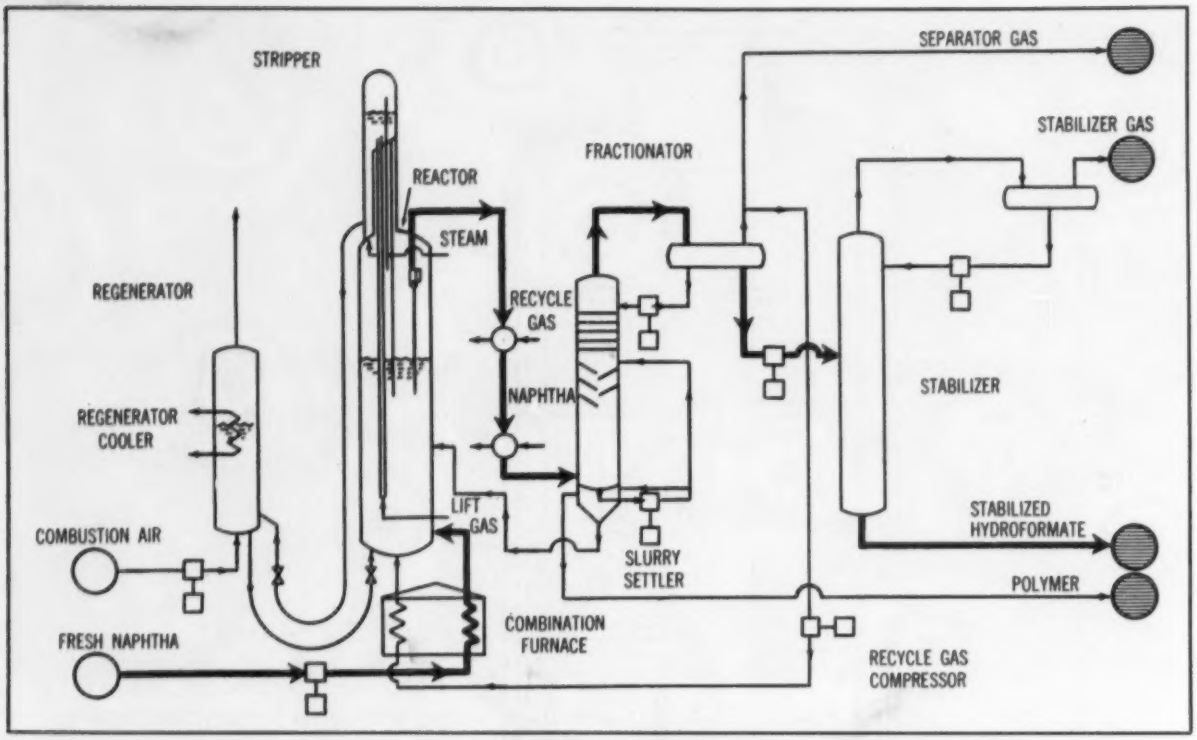


FIGURE 14—Fluid hydroforming.

and piping in fixed-bed hydroforming units have been presented by Darling.[72]

The operation of a hydroformer in series with a thermal reforming unit has been suggested by Welty.[321] The addition of from 0.001 to 0.2 percent oxygen to the hydrogen recycle stream in reforming over a molybdena-alumina catalyst has been suggested by Beckberger and Woerner.[31, 32] The operation of fixed-bed hydroforming units with primary emphasis on wartime aromatics production has been discussed by Weber[313] and by Marshall.[203] A flow diagram of a typical commercial fixed-bed hydroforming unit is shown in Figure 12.

The operation of an adiabatic pilot hydroformer has been described and comparison of operating data from this unit with data from a commercial hydroformer has been presented by Berg, Fawcett, and Dhondt.[40] Constructional details of a fixed-bed hydroforming pilot plant have also been presented by Yule and Bennett.[325]

The necessity for providing alternate sets of reactors to permit reforming in one while another is being regenerated, and the complicated valving and timing system, require about 60 percent more capital investment than either polyforming or thermal reforming plus polymerization, according to Kastens and Sutherland.[152]

A fixed-bed reforming process employing hydrogen recycle and a molybdena-alumina catalyst developed by Standard Oil Company of California is quite similar to other fixed-bed hydroforming processes. This process was first developed for the production of toluene and has also been successfully applied to the manufacture of high-octane gasoline. The process is described by Saegebarth[273] and incorporates some unique features in reactor design as described by Burton, Chiswell, Claussen, Huey and Senger.[58] As described by Burton et al.[58] and as illustrated in Figure 13, each reactor contains a number of catalyst beds. Feed enters at the center of the periphery of the reactor, travels both up and down in an annular space, and enters the top of each bed from openings in this annular space. Reaction products exit from the bottom of each bed into a central duct.

In hydroforming, as in thermal reforming, the principal by-product is a light gas. In hydroforming, however, the by-product gas is mostly saturated and cannot be polymerized. A heavy hydropolymer is also produced, as already described under the section on Aromatics Recovery."

With Moly Catalysts—Fluid Hydroforming—The basic hydroforming catalyst and process just described has been successfully combined with the fluidized solids technique to yield the fluid hydroforming process. As shown in the basic flow diagram in Figure 14, the heavy naphtha charge first picks up heat from the reaction products in a heat exchanger, then enters a fired heater, from which it is delivered directly into the reactor as a superheated vapor. Vapors leave overhead from the reactor and are condensed. A portion of the uncondensed gas is reheated in the fired heater, providing much of the heat of reaction. This gas also provides the hydrogen atmosphere in which the catalytic hydroforming reaction occurs.

Since the hydroforming reaction is an endothermic reaction in which large quantities of heat must be supplied over a narrow temperature range for optimum process efficiency, it is ideally suited to fluidized solids operation. In the fixed-bed reactor, the entrance temperature is higher than the desired temperature, and the exit temperature is lower.

As discussed by Anon,[10] a study of fixed-bed hydro-

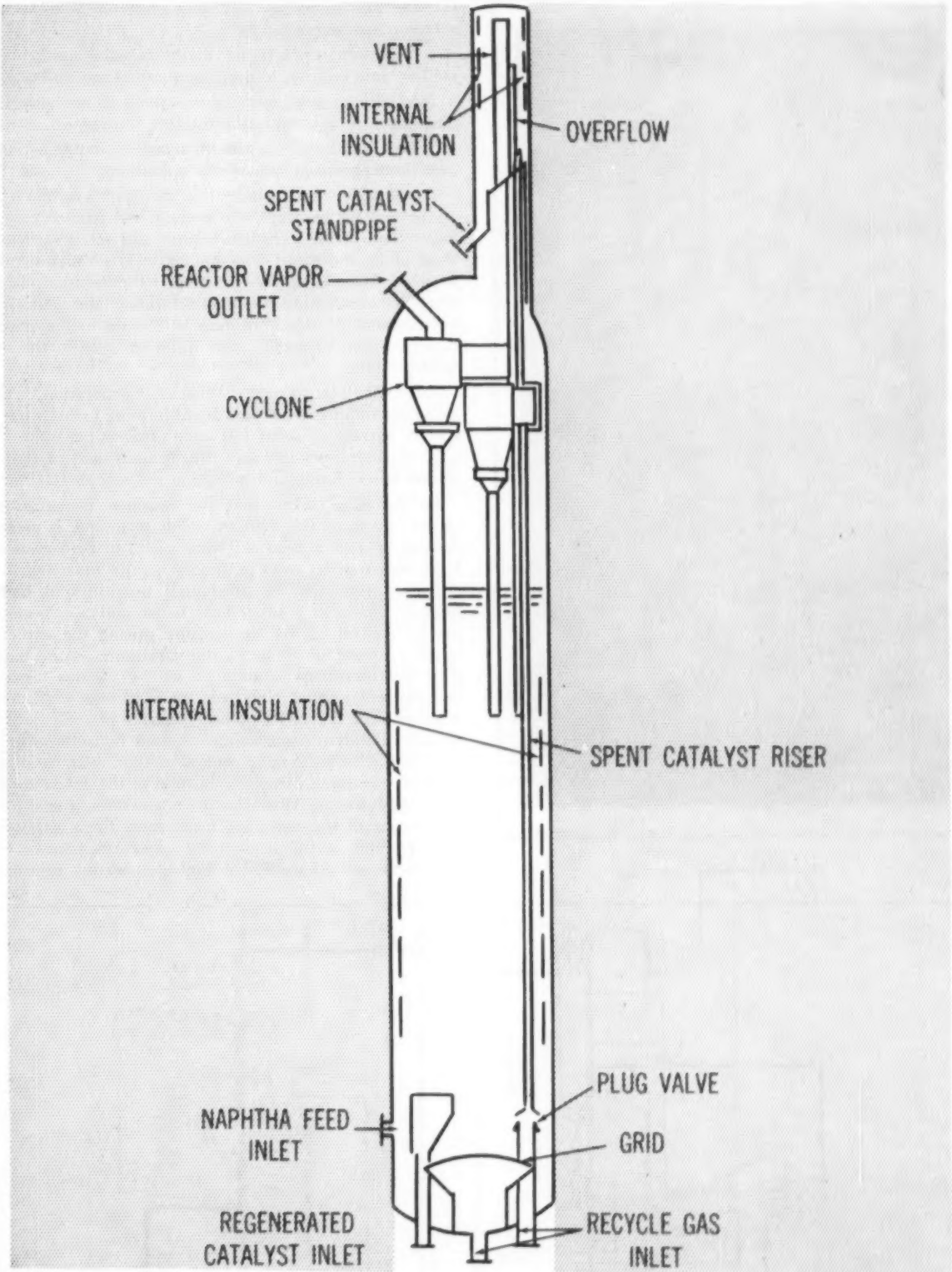


FIGURE 15—Reactor and stripper.

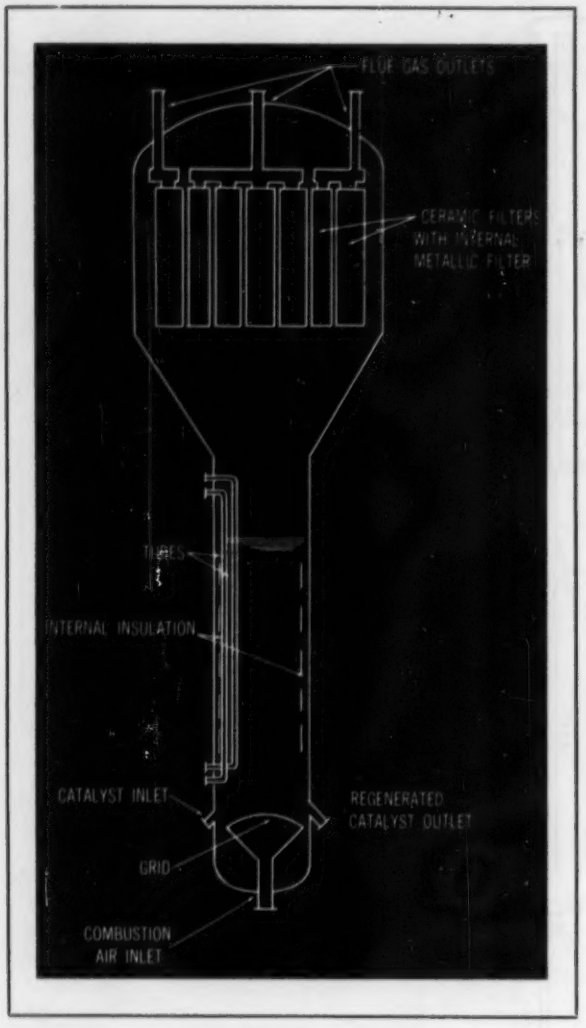


FIGURE 16—Regenerator.

forming operations revealed that optimum yield-octane relationships were given by:

1. Minimum contact time in the furnace and reactor void volume in order to decrease thermal pre-cracking.

2. Maximum possible catalyst activity to minimize the temperatures required in the reactor.

3. Isothermal reaction conditions which improve yields over those produced in adiabatic operations.

In a fluidized bed, where the entire bed is within 5 F. of the exit temperature, the average bed temperature is lower than in the fixed-bed reactor and yet is sufficient to produce the same or a higher yield of high-octane product. Because of this excellent temperature control, there is considerably less over-reforming and under-reforming and considerably more selectivity in the conditions required to achieve the optimum yield of the desired product.

According to Foster Wheeler Corporation,[11] the molybdena-alumina gel fluid hydroforming catalyst has a specific surface of about 100 square meters per gram. In a 10,000-barrel-per-day unit, this is equivalent to 10,000 square miles of catalytic surface in the reactor bed.

By the same token that the excellent heat-transfer characteristic of the fluidized solids technique is of advantage in reaction, so is it very useful in regeneration. High heat-transfer rates in the regenerator make possible efficient production of substantial quantities of high-pressure steam in a waste-heat boiler and also permits precise control of the temperature during the carbon-burning operation. Some of the variations on the basic fluid hydroforming technique made by various process development groups have been made to take maximum advantage of the efficient heat-transfer possible in this process. Catalyst regeneration in fluid hydroforming is accomplished by the same general method as in catalytic cracking—through direct combustion of the coke deposit with undiluted air. However, the regenerator is less than 10 percent of the size of a regenerator for a catalytic cracking unit of the same feed capacity because of, (1) lower carbon yield, (2) higher operating pressure,

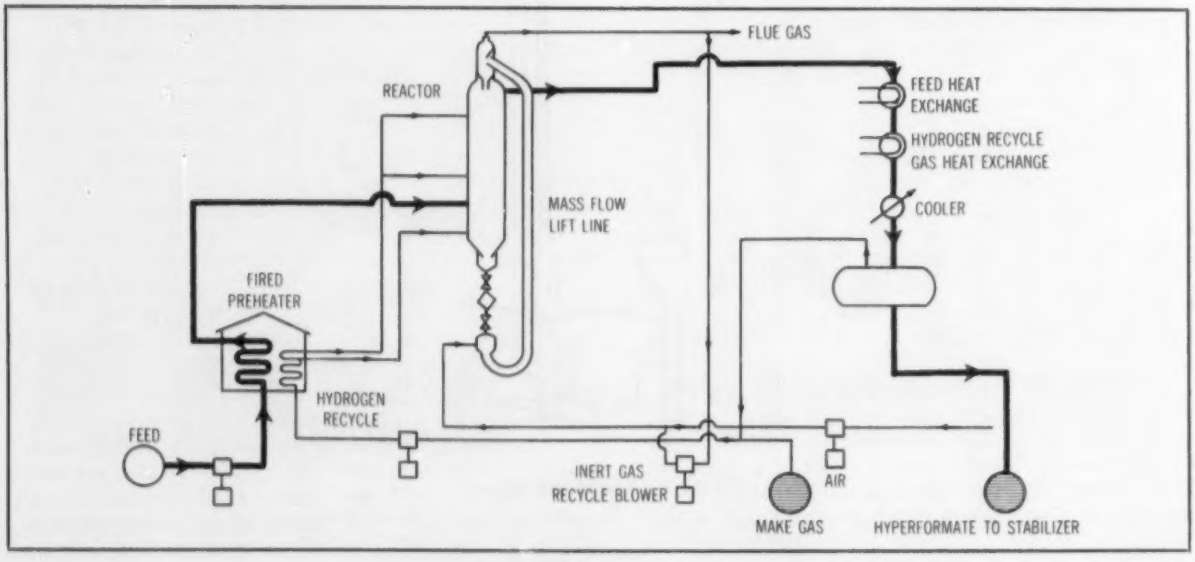


FIGURE 17—Hyperforming.

and, (3) faster burning rate of carbon on the hydroforming catalyst.

As described by McGrath,[214, 215] a 3-bpd fluid hydroforming pilot plant was operated to permit quantitative evaluation of the fluid hydroforming technique as compared to the then-known thermal reforming and fixed-bed hydroforming process. A reactor about 45 feet long and 3 inches in diameter was employed. The reactor effluent was passed through porous stainless steel filters and thence to condensers and a separator. At intervals, a portion of the spent, carbonized catalyst was withdrawn and replaced with regenerated catalyst. A third vessel, identical to the pilot plant reactor and regenerator, was used for the storage of regenerated catalyst. Experience with this type of pilot plant indicated the following advantages over fixed-bed hydroforming:

1. Lower investment and operating costs.
2. Steady-state operation without the necessity of a shutdown for catalyst removal.
3. Longer catalyst life due to better temperature control during regeneration.
4. Elimination of the complicated time-cycle control.
5. Elimination of multiple reactors and avoidance of having to design a reactor for both reaction and regeneration.
6. Isothermal reaction which is superior from a selectivity standpoint.
7. Simpler, easier and cheaper regeneration.
8. More efficient catalyst utilization due to elimination of the channeling sometimes encountered in fixed-bed operation.

Other data on fluid hydroforming and an economic comparison between fluid hydroforming and thermal reforming plus polymerization have been presented by Shepardson, Tyson, and Voorhies.[278] Investment, utility, and catalyst costs for fixed-bed and fluid-bed hydroforming have been compared by Weber.[311]

The first commercial fluid hydroforming unit was

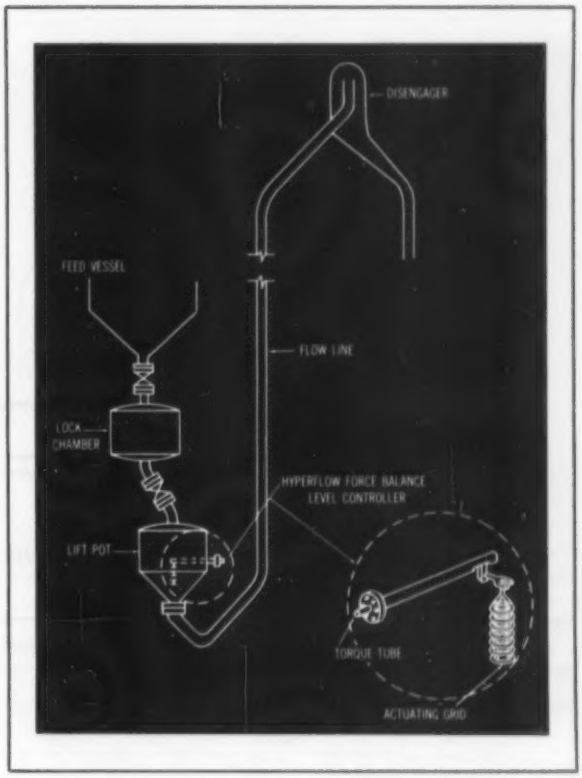


FIGURE 18—Hyperflow transfer system.

that at the Destrehan, La., refinery of Pan-Am Southern Corporation. This unit was built in 1952 and went on stream in June, 1953. This first 2000-bpd unit was described by Seebold, Bertetti, Snuggs, and Bock[275] and by Anon.[12] The mechanical design of this unit has been described in more detail by Harang[144] and the flow scheme

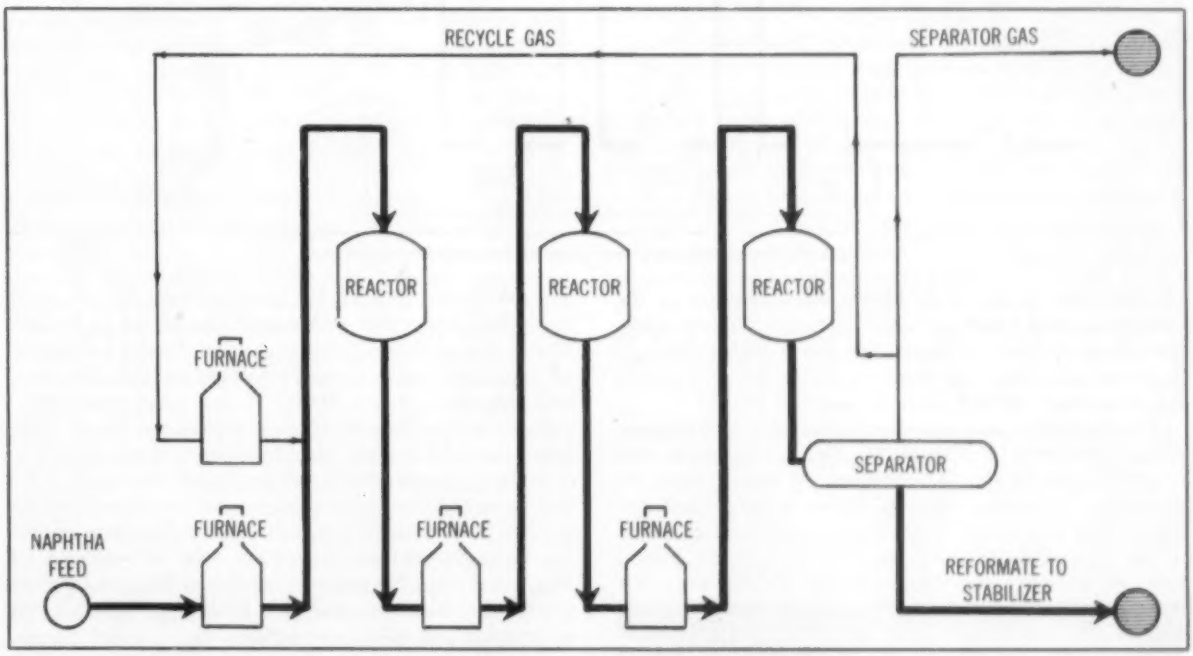


FIGURE 19—Non-regenerative platinum reforming.

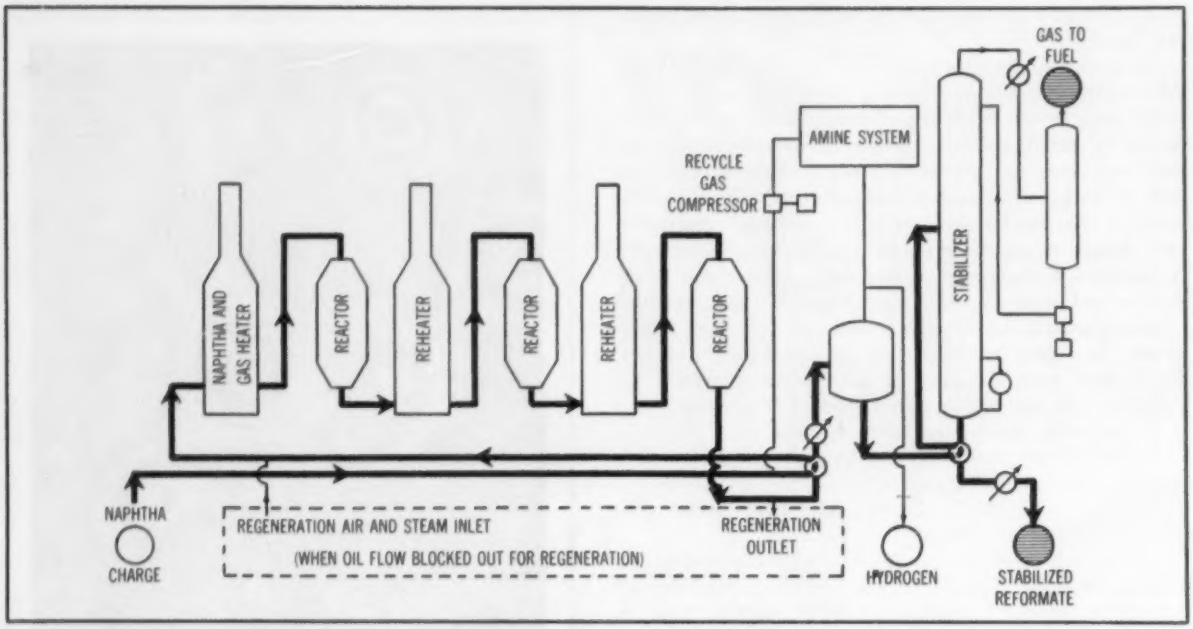


FIGURE 20—Regenerative platinum reforming (blocked-out operation).

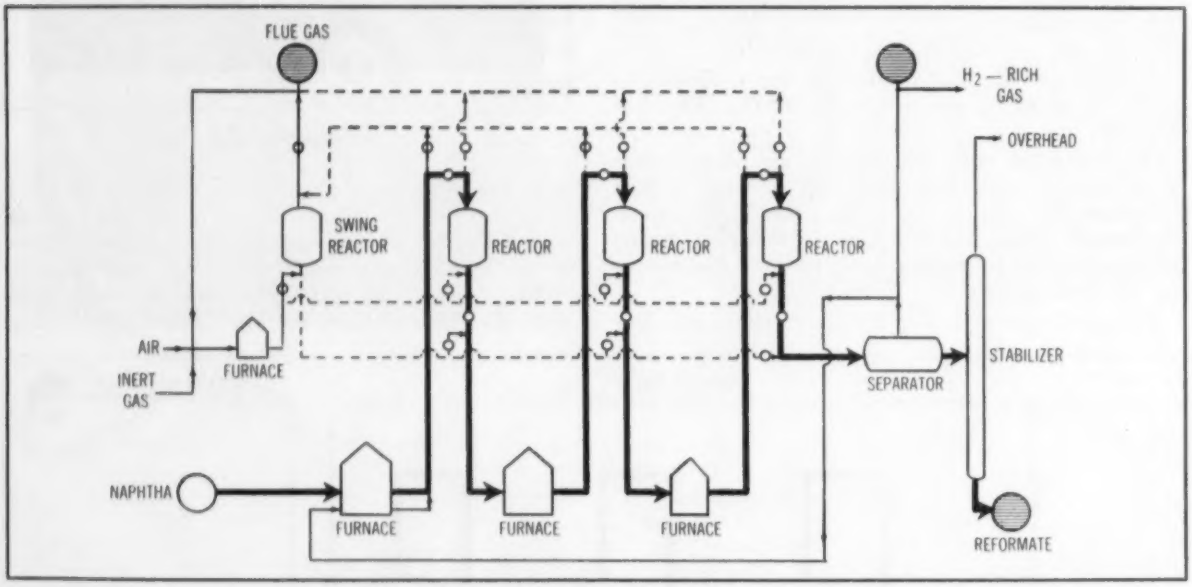


FIGURE 21—Regenerative platinum reforming (swing-reactor operation).

of this plant is shown in Figure 14. A section of the reactor-stripper vessel is shown in Figure 15 and a section of the regenerator vessel is shown in Figure 16.

Actual operating experience with the Destrehan unit has been reported by Ferrell, Tusson and Parker.[94]

The Destrehan unit was the original fluid hydroformer design developed by The M. W. Kellogg Company and employed side-by-side arrangement of reactor and regenerator. A modified Kellogg design is the Orthoforming process which applies the stacked single-vessel design of the Orthoflow catalytic cracking unit to the hydroforming process. The Orthoforming arrangement has been described by Richards[262] and by Richards and Tarnpoll.[263]

In addition to the fluid hydroformer designs primarily associated with The M. W. Kellogg Company, there are two types designated as Model I and Model II by Esso Research and Engineering Company. Model I is similar to the side-by-side design employed in the Destrehan unit described above. Model II, however, represents a radical design departure, as outlined by Tyson, Gornowski and Nicholson[303] and by Anon.[13] A second solid—a relatively coarse, dense, inert solid—is circulated in the system in addition to the catalyst, and specifically for improved heat transfer between regenerator and reactor. Lower investment and operating costs are claimed for the new design. No commercial Model II units have yet been built, however, and this process variation is still undergoing pilot-plant development.

A number of patents have recently been issued on

specific flow configurations and arrangements of equipment in fluid hydroforming. These include patents by Hardy et al,[145] by Rex,[260] by Blanding,[50] by Hemminger,[158] by Hemminger and Taff,[159] by Weikart,[318] and by MacLaren.[200]

With Moly Catalysts—Hyperforming—Hyperforming, a development of Union Oil Company of California, uses a molybdenum catalyst—but uses cobalt molybdate rather than molybdena-alumina. Also, it is the only one of the molybdenum catalyst processes to use a moving pelleted bed. Further, the moving solids are conveyed by a unique solids-conveying technique known as Hyperflow.

The Hyperforming process was first disclosed by Berg.[35] Further process details have been published by Berg.[36,37] Details of the first commercial Hyperformer, an 1100-bpd unit at Signal Hill, Calif., have been presented by Berg.[38] A flow diagram is shown in Figure 17.

The Hyperflow technique for solids movement has been detailed by Anon[14,15] and is illustrated in Figure 18.

With Platinum Catalysts—Reforming processes using platinum catalysts fall into three general classes:

1. Non-regenerative processes. Figure 19 shows the flow scheme for this type of process.

2. Processes which can regenerate the catalyst if regeneration is made necessary by an operating upset. This type usually takes the form shown in Figure 21.

3. Processes which employ cyclic regeneration to maintain catalyst activity. These may be of the blocked-out type where the entire reactor train is alternately engaged in reaction or regeneration. Alternatively, a swing reactor may be used so that one reactor is being regenerated while the others are all on stream. These two types are shown in Figures 20 and 21, respectively.

With Platinum Catalysts—Platforming—The Platforming process was announced by Nelson[229] of Universal Oil Products Company in March, 1949. Its designated purpose was to improve straight-run or natural gasoline, and the success of the process was in part attributed to the use of platinum as a catalyst. Dr. Vladimir Haensel conceived the original idea and directed subsequent research. The desirable features of (1) large ON gain, (2) low volumetric loss (3) moderate plant and operating costs were claimed. It is a fixed-bed, platinum-catalyst process and its distinguishing feature is that it employs a non-regenerative catalyst as illustrated in the flow scheme in Figure 19. The composition of the Platforming catalyst has been disclosed by Haensel.[124,125] It essentially consists of 0.01 to 1.0 percent platinum, alumina, and combined halogen (0.1 to 8.0 percent of fluorine or chlorine based on alumina).

Platforming was the first of the platinum-catalyst reforming processes to be put in commercial operation. The first unit was that at Old Dutch Refining Company in Muskegon, Mich., and it went on stream in October, 1949, as described by Anon.[16] The straight-run naphtha feed is taken from storage, passed in heat exchange with the reactor products, and fed to a prefractionator. A center cut of 175-375 F. boiling range is taken as feed to the Platformer. The light overhead is removed because it would not be materially improved by Platforming, and water is removed at the reflux drum. The heavy bottoms are removed because of any contaminants they might contain and because large amounts of heavy material in the feed (caused by crude still upsets, for example)

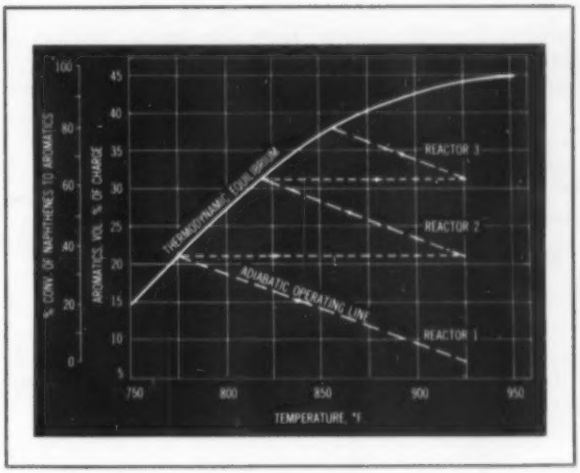


FIGURE 22—Prediction of reforming conversion.

would cause excessive coking and might require a shutdown of the Platforming unit. These bottoms are marketed as Diesel fuel or light distillate fuel.

The 175-375 cut is heated to 500 F. by heat exchange with reactor effluent and is then pumped to the coil of a fired heater. The stock leaving the heater at 900-950 F. joins the recycle gas stream, which is at about that same temperature, and enters the first of three reactors.

The reactors are all cylindrical in shape with conical bottoms and are ceramic lined to maintain the carbon steel walls at relatively low temperatures so alloy construction will not be necessary. A steel cone surrounded by wire mesh is located at the bottom of the reactor and this assembly in turn supports a graded bed of alumina balls, graduated from one inch in diameter at the bottom to ⅜-inch in diameter at the top. The pelleted catalyst is then charged and a layer of one-inch alumina balls finally surmounts the catalyst bed to aid in distribution of the downward-flowing charge vapors.

Since the over-all Platforming reaction is endothermic, it is necessary to add heat between reactors. Actually, the heat requirement is greatest in the first reactor and decreases progressively until the third reactor operates at very nearly isothermal conditions. In a typical installation, a single heater, end-fired, with a dividing center wall provides the necessary intermediate heating between the first and second and the second and third reactors.

The product stream from the third reactor is passed through a series of heat exchangers, cooled to 100 F. and fed to a gas separator. The uncondensed gases contain 80-85 percent hydrogen with the balance consisting of light hydrocarbons (mostly methane). A portion of the gas is recycled through a compressor and a fired coil whence it joins the feed stock at 900-950 F. The liquid product from the separator is sent to a stabilizer column of conventional design.

Modifications may be made in the operation of a Platforming unit to permit production of maximum yields of aromatics, rather than of high-octane motor fuel. This type of operation has been discussed by Haen-

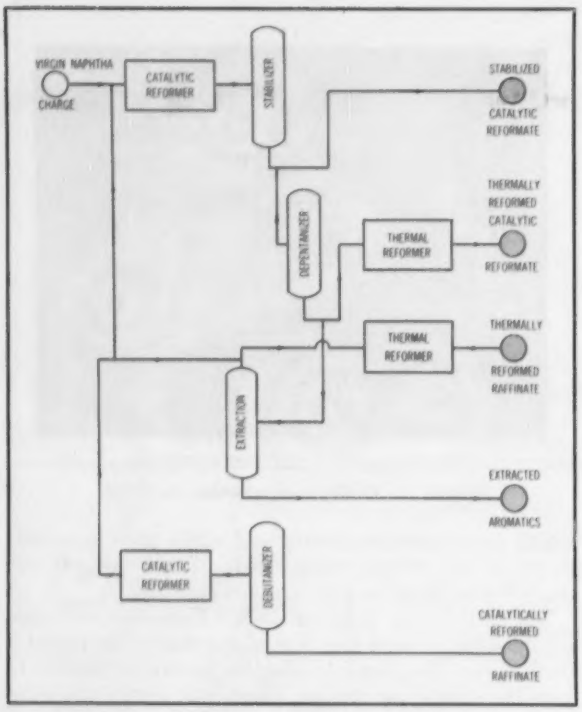


FIGURE 23—Combinations of reforming with other processing.

sel and Berger.[133]

The various reactions over the Platforming catalyst have also been described by Haensel and Donaldson.[134]

Performance figures on the Old Dutch Platforming unit have been presented by Haensel and Sterba.[140] They indicate that 45 barrels of charge were processed per pound of catalyst in one run and 42.3 barrels of charge per pound were processed in a second run. Actual catalyst costs for this operation were about 9 cents per barrel of feed. The results of three years of commercial Platforming have been reported by Weinert, Sterba, Haensel and Grote.[320]

The design and construction of the Platformer at Eastern States Petroleum Company in Houston have been described by Martin.[205]

The instrumentation of the Platforming unit at Midwest Refineries in Alma, Mich., has been described in detail by Anon.[17]

The product from Platforming, designated as Platformate, is claimed to have several unique features, as pointed out by Bland[49] and by Bogen and Haensel.[52]

1. It is olefin-free (in contrast to thermally or catalytically cracked gasolines).

2. It is composed primarily of isoparaffins and aromatics, with only a small amount of normal paraffins.

3. It is unusually low in sulfur (90-95 percent of the sulfur in the charge is removed in Platforming).

These features of composition are claimed to offer material advantages in product behavior:

1. Improved stability as compared to cracked gasolines (due to absence of olefins).

2. Good lead susceptibility and utilization (due to low sulfur content and low olefin content).

3. High octane rating (because of high aromatic and isoparaffin contents).

4. Road octane number usually above Research octane number.

The combination of Platforming with selective solvent extraction of the gasoline product and recycle of the resulting low-octane, highly-paraffinic raffinate results in the Rexforming process, announced in March, 1955. The process has been described by Grote, Haensel and Sterba.[119] The Rexforming porcess is one of the possible combinations of reforming with aromatics separation and further reforming illustrated in Figure 23.

In the Rexforming process, the reformate having an F-1 octane number of 75 to 85 clear and containing 35-45 percent aromatics passes to a stabilizer column (essentially a debutanizer) as in the conventional Platforming process. Then, however, the stabilized product goes to a selective solvent extraction unit.

As discussed by Weber,[315] the glycol solvent used in the extraction unit of the Rexforming process is similar to that used in the Udex process. It is designed, however, to be less selective and it absorbs in the extract not only most of the aromatics but also the lower-boiling paraffins which have good octane numbers. The Rexformate may contain 60-65 percent aromatics.

The raffinate from the extraction unit contains the higher-boiling, less-soluble paraffinic components. This becomes the recycle stock which combines with the fresh feed to the reactors. The extraction process need not be extremely effective since any aromatics left in the recycle stock are not discarded, but are returned to the reactors.

Recycle operation in the Rexforming process permits operation at temperatures perhaps 50 F. below those used in a once-through Platforming operation, and at higher space velocities. Since these milder conditions degrade less charging stock, higher over-all yields are possible. A balance is struck in Rexforming between dehydrocyclization and hydrocracking, and excessive coke and gas formation are avoided.

The paraffinic recycle stream may amount to as much as 50 percent of the charge and generally amounts to 20 to 40 percent of fresh feed. This material may alternately be marketed as jet fuel when recycling is not desired. When recycling, the higher space velocities at the milder operation conditions will permit the use of the reaction section of existing Platforming units for the increased charge rate without the provision of additional catalyst.

Aside from the Rexforming variation, a number of adaptations of the basic Platforming process may be made as outlined in a series of patents by Haensel,[132] by Murray and Haensel,[227] and by Haensel and Gerhold.[137] Thus, naphtha may be fractionated into a light and a heavy fraction. In the Murray and Haensel patent, the light naphtha is passed over a platinum-halogen-alumina catalyst at 50-400 psi and then the heavy fraction is reformed over the same catalyst at 500 psi. In the Haensel and Gerhold patent, the low-boiling fraction is reformed at high intensity over a catalyst containing more halogen than the second-stage catalyst which is used to reform the high-boiling fraction at lower intensity. In the Haensel patent a charge is first subjected to a high pressure hydrocracking step over a platinum-halogen-alumina catalyst at a weight hourly space velocity (WHSV) of 0.2 to 5.0. The stock is then passed to a lower pressure aromatization step over a platinum-alumina catalyst at a high WHSV of 2 to 20.

With Platinum Catalysts—Catforming—The Catforming process was developed by the Atlantic Refining Company. The catalyst consists of a unique combination of a hydrogenating agent, platinum, with an acidic silica-alumina cracking catalyst. As discussed by Anon,[18] these catalysts possess high activity and selectivity for the isomerization of alkanes and cycloalkanes, as well as for the hydroisomerization of unsaturated hydrocarbons.

It has been stated by Benedict[34] that no feed pretreatment is required before Catforming to remove water, sulfur, nitrogen compounds, or contaminants such as arsenic in the amounts normally found in refinery stocks. However, it should be recognized that there are definite upper tolerance limits on all these contaminants.

The Catforming process, whose flow diagram is shown in Figure 20, differs from Platforming in that regeneration may be employed. The announcement of the process in 1951 was described by Anon.[19]

The main feature which differentiates Catforming from Platforming is the catalyst composition, which has been described by Ciapetta[60] and by Ciapetta and Buck[61] and by Ciapetta and Hunter.[62] Operating features which result from the use of this specific catalyst include operation at relatively high space velocities (of the order of 5.0), production of a recycle gas of very high hydrogen purity (97-98 percent), and the ability to undergo regeneration.

Regeneration is practiced as a means of prolonging catalyst life and is accomplished by passing a dilute mixture of air and steam through all the reactors at the same time. Regeneration is conducted at approximately atmospheric pressure.

Whether regenerated or not, it is expected that a charge of Catforming catalyst will have to be replaced with fresh material (and the platinum recovered) about once a year due to metal poisoning and gradual deactivation over a period of time.

The ability of the Catforming catalyst to be regenerated by an air-steam mixture highlights the fact that water has no harmful effect on the catalyst. Fowle, Bent, Milner and Masologites point out,[102] that a five-month, pilot-plant run was conducted during which water in amounts up to 1 weight percent was injected into the reactor feed with no ill effects on catalyst activity or product distribution. This resistance to water also makes it possible to use a conventional desulfurization process on the recycle gas when charging sulfur-containing stocks. In the event of an upset in the operation of an amine scrubber for sulfur removal, the amines would cause a temporary decline in catalyst activity, which is quickly restored when amines are no longer present in the feed.

Sulfur is only a temporary catalyst poison but at feed sulfur contents of 0.03 to 0.04 percent sulfur, the depression of catalyst activity becomes serious enough to justify corrective action, such as desufurization of the recycle gas.

The first commercial Catforming unit was that at the McBride Refining Company as described by Faulkner, Milner and Grebe[93] and by Milner.[220] Operating results after a year's operation of the McBride unit as well as a unit at Malco Refineries, Inc. at Prewitt, N. M., have been reported by Grane.[114] Regeneration had been successfully carried out at the McBride unit. The Malco unit had not yet required regeneration and catalyst life had already exceeded 50 barrels of naphtha charge per pound of catalyst and no change in catalyst activity had been noted since the beginning of the run (reactor temperature is gradually increased when an activity decrease occurs and before regeneration).

The commercial operation of an 8000-barrel-per-day Catformer at the Atreco, Texas, refinery of The Atlantic Refining Company has been described by Foster.[99] The average sulfur content of the feed to this plant has been 0.14 percent and amine scrubbing of recycle gas was employed. A ratio of 9 moles of hydrogen per mole of liquid feed is employed in the reactors.

A two-stage Catforming operation for the conversion of cumene to methylethylbenzenes and trimethylbenzenes has been described by Pitts, Connor, and Leum.[248] In a first, lower-temperature step, the hydrogenation of aromatics and isomerization of the resulting naphthenes predominate and in a second higher-temperature step, the dehydrogenation and dehydroisomerization of naphthenes and the isomerization of alkyl aromatics predominate. A single-step, high-temperature Catforming treatment gave nearly complete dealkylation rather than the desired alkylbenzenes.

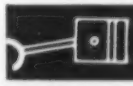
With Platinum Catalysts—Houdriforming—The present-day Houdriforming process is a platinum-catalyst process utilizing what is known as the Houdry Type-3 catalyst consisting of platinum on an acid support as described by Bland.[48]

There actually was an earlier Houdry reforming process, as described by Peterkin, Bates and Broom.[245] This process employed the same aluminosilicate catalyst as that used in the Houdry cracking process. The preferred operating temperature was 875 to 925 F. as specified by Houdry.[172] When reforming naphthas, the throughput rate was almost doubled as compared with the cracking of gas oil (2 volumes of naphtha per hour per volume of catalyst).

The Houdriforming process was first described by Kirkbride.[188] The application of the Houdriforming process to the production of aromatics and of high-octane gasoline has been further described by Heinemann, Schall and Stevenson.[155] Houdriforming operations at low pressure have been discussed by Dart, Oblad and Schall.[73]

Data on the Houdriforming of the naphtha products from hydrocracking processes have been presented by Heinemann, Hattman, and Schall.[152] Their results show that hydrocracked naphthas behave much like virgin naphthas when subjected to Houdriforming. Work on the Houdriforming of straight-run naphthas had previously been reported by Noll, Burtis, and Dart.[233] Additional data on Houdriforming reactions has been presented by Heinemann, Mills, Oblad, Milliken, Hattman and Kirsch.[154]

Some economic comparisons of the application of Houdriforming to a variety of refinery processing schemes have been presented by Burtis and Noll[57] and more recently by Noll, Burtis, and Dart.[233] Four general cases are considered: (1) thermal cracking plus thermal reforming; (2) thermal cracking plus Houdriforming; (3)



Houdriflow cracking plus thermal reforming; and (4) Houdriflow cracking plus Houdriforming.

The first commercial Houdriforming unit was the 12,000-bpd installation for Sun Oil Company at Marcus Hook, Pa., as described by Beyler, Stevenson and Shuman.[45] Details of the ¼-bpd pilot plant from which this unit was designed, and comparisons of the operation of the pilot plant and of the commercial plant are given by these authors. The flow diagram typical of a Houdriformer is shown in Figure 20. A series of three reactors was chosen on the basis of graphical prediction from equilibrium data and operating results under adiabatic conditions as shown in Figure 22.

The Houdriforming unit at Crown Central Petroleum Corporation's refinery at Pasadena, Texas, has been described by Anon.[20] A unique feature of this particular unit is a pre-treater or "guard case." Such a guard case was first installed in Ohio Oil Company's Houdriformer at Robinson, Ill. This modification consists of a small catalytic reactor and a stripper tower, operated at a pressure slightly below the operating pressure of the Houdriformer flash drum. No reforming takes place in this guard case due to the mild operating conditions, but lead and copper salts are removed, sulfur compounds are converted to H_2S, and any olefins present are hydrogenated. The product from this guard case is partially cooled, stripped with recycle hydrogen, and sent through a furnace to the reactors of the Houdriforming unit.

A recent modification of the basic Houdriforming technique is "Iso-Plus" processing which may take two general forms (See Figure 23).

1. Houdriforming at moderate severity combined with aromatics separation (in an Arosorb or other aromatics extraction unit) and separate (or recycle) Houdriforming of the paraffinic concentrate.
2. Houdriforming at moderate severity combined with thermal reforming of the Houdriformate and catalytic polymerization.

These were described by Noll, Schall, Craig and Stevenson.[234] The Iso-Plus processing scheme including thermal reforming is stated to be the most attractive economically, but the variation involving aromatics separation has the highest potential for both octane number and yield of motor gasoline. A patent by Oblad and Heinemann[235] discloses one over-all processing scheme built around catalytic reforming.

With Platinum Catalysts—Esso Process—The most recent of the platinum catalyst processes is that of Esso Research and Engineering Company. It is understood that the process, whose flow essentials are shown in Figure 20, closely resembles Ultraforming. However, a swing reactor is not necessarily in the Esso process and, as shown in Table 4, regeneration may be occasional, rather than cyclic. The catalyst for the Esso process is being manufactured by Davison Chemical Company, who also make the Catforming catalyst.

With Platinum Catalysts—Sovaforming—Sovaforming is the name Socony Mobil Oil Company has applied to the fixed-bed platinum catalyst reforming process now being installed in Socony refineries. This is a high-pressure process which generally operates without regeneration. Facilities are provided, however, so that regeneration can be carried out if an operating upset causes excessive coke deposition on the catalyst, as illustrated in Figure 20.

With Platinum Catalysts—Ultraforming—Ultraforming is a development of Standard Oil Company (Indiana) and differs from most other platinum catalyst processes in that it is basically a low-pressure, regenerative process.

As pointed out in the early sections of this article, there are a number of advantages to be gained from the operation of a catalytic reforming unit at lower pressures. For example, Figure 2 shows the beneficial effects of low pressures on the methylcyclohexane-toluene equilibrium. Broadly, lower pressure operation results in:

1. Higher gasoline yields (as indicated in Figure 11) resulting from less hydrocracking.
2. Higher product octane levels from a given naphtha charge stock.
3. Better hydrogen yields due to an increase in dehydrogenation as well as reduced hydrogen consumption in hydrocracking at lower pressures. (Net hydrogen make in Ultraforming is 1100 scf per barrel as compared with 700 scf per barrel for fluid hydroforming according to Forrester, Conn, and Malloy.[97])

However these advantages are not available in a practical commercial process unless one can successfully regenerate a platinum catalyst a number of times; herein lies the advantage of the Ultraforming process. Once regeneration can be successfully practiced, an additional advantage is obtained in the form of increased operating flexibility, since the catalyst is less affected by variations in feed composition or operating conditions.

The Ultraforming process has been described by Forrester, Conn and Malloy,[97] by Birmingham,[47] and by Roberts, Thiele, and Shankland.[265] Some basic comparisons of regenerative platinum reforming (as represented by Ultraforming) with non-regenerative platinum reforming and with fluid molybdena reforming have been presented by Steel, Bock, Hertwig and Russum.[289]

The flow diagram of the Ultraforming process is shown in Figure 21. The noticeable feature which differentiates it from the platinum-catalyst processes discussed so far is the provision of regeneration facilities in the form of a swing reactor, permitting regeneration with no interruption of on-stream time. As pointed out by Forrester, Conn and Malloy,[97] regeneration insures operating flexibility and guarantees against damage from operational upsets. These authors point out that during pilot plant operations, Ultraforming catalysts have been subjected to reforming temperatures as high as 1130 F., to pressures as low as atmospheric, to periods without hydrogen recycle, and to feeds boiling as high as 540 F. Although deactivation was severe in each case, activity was completely restored by the regeneration technique. Birmingham[47] points out that the regeneration step in Ultraforming goes beyond the mere removal of carbon and completely restores the catalyst to fresh condition.

It is claimed that, in contrast to other regenerative platinum catalyst processes, Ultraforming does not require a distinctly shorter operating cycle after each regeneration, and that replacement of catalyst is not required even after 2-5 regenerations.

The Ultraformer at the Montreal refinery of Canadian Petrofina has been described by de Haulleville.[148]

With Platinum Catalysts—Sinclair-Baker Process—The Sinclair-Baker process has been a joint development of the Sinclair Research Laboratories and of Baker and Company which has resulted in a unique platinum re-

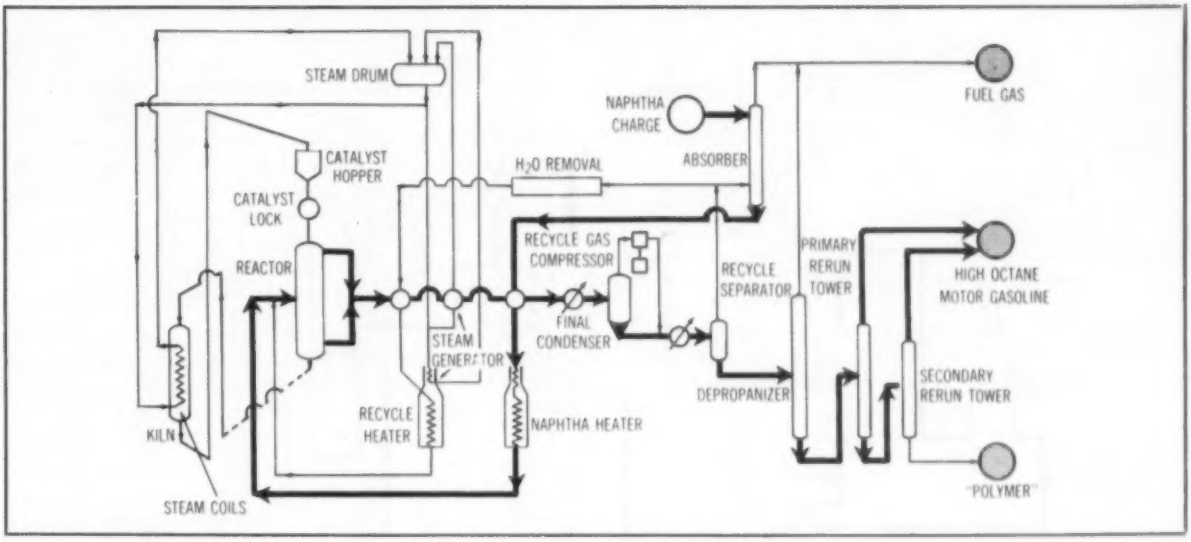


FIGURE 24—Thermofor catalytic reforming.

forming catalyst. As pointed out by Teter, Borgerson, and Beckberger,[297] this catalyst has two major advantages:

1. A high ratio of paraffin cyclization activity to hydrocracking activity.

2. An ability to be regenerated with dilute air.

The length of time between regenerations varies widely with variation in operating conditions. The length of the naphtha processing cycle is increased by (1) high pressure, (2) high naphthene content feed stock, (3) low space velocities, (4) high recycle gas ratios, (5) production of low-octane reformates, and (6) decreased number of regenerations.

With paraffinic naphtha and requirements for reformate above 90 octane clear or for high aromatics content, regenerative operation will be required in general, although the catalyst is being offered for fixed-bed units operating with or without regeneration.

A flow diagram for the Sinclair-Baker process, as described by Decker[76] and Weber[314] is shown in Figure 20.

Operating experience with the Sinclair-Baker catalyst at the Sinclair refinery at Marcus Hook, Pa., has been reported by Decker and Stewart.[77] As pointed out by these authors, temperatures are increased from reactor to reactor to compensate for the gradual reduction of activity caused by coke deposition on the catalyst, carbon laydown tending to be highest in the last reactor in the series in catalytic reforming units in general. Catalyst carbon contents run about 6.0 weight percent before regeneration and 0.2 weight percent after regeneration, according to Decker and Stewart.[77] Details of startup, depressuring and purging, and regeneration are also given by these authors. Regeneration is carried out in three stages: (1) A low temperature burn (preburn) at 500 F.; (2) A second (main) burn at 750 F.; and (3) A final burn between 920 and 940 F. The burning periods used in the Marcus Hook unit were 11 hours for the first burn and 14 hours for the second burn.

With Other Catalysts—Thermofor Catalytic Reforming—The TCR process is one of the two moving-bed processes among the many catalytic reforming processes. It is the only one of the catalytic reforming processes to employ a catalyst of its particular form and composition—a chromia-alumina gel bead catalyst. The process was first announced in 1950 as described by Anon.[21]

The evolution of this particular chromia-alumina reforming catalyst was first discussed by Standard Oil Company (Ohio) researchers Hughes, Stine and Darling,[175] although patents had already been granted to Burk and Hughes[56] and to Hughes.[174] An outstanding feature of the catalyst composition was stated to be that it enabled coke deposition to be controlled at a low level by a lower partial pressure of hydrogen than is used with any other catalyst. The patents on the catalyst were sold to Socony by Sohio and the TCR process was developed by Socony. A cooperative paper by Sohio and Socony researchers Hughes, Eastwood et al.[176] has given additional details on the performance of the final commercial catalyst.

The commercial TCR process whose flow scheme is shown in Figure 24 has been described in detail by Payne, Evans, Bergstrom and Bowles.[243]

Compared with Thermofor catalytic cracking (TCC) units, the coke laydown in the TCR process is very low and moving catalyst circulation is comparatively small—less than 10 percent of the amount circulated in modern air-lift TCC units. Since the catalyst flow is comparatively small, ranging from 5 to 50 tons per hour for units having throughputs up to 20,000 bpd, bucket elevators are employed.

In units such as the TCR, Fluid Hydroforming, and Hyperforming units, the catalyst-to-naphtha ratio is added to the four other basic operating variables which pertain to most of the other catalytic reforming processes —temperature, pressure, space velocity, and hydrogen recycle rate. Actually, as discussed by Hughes, Eastwood et al.,[176] changes in catalyst-to-naphtha ratio have shown but little effect on yield or product quality.

How To Get Those Top Octanes

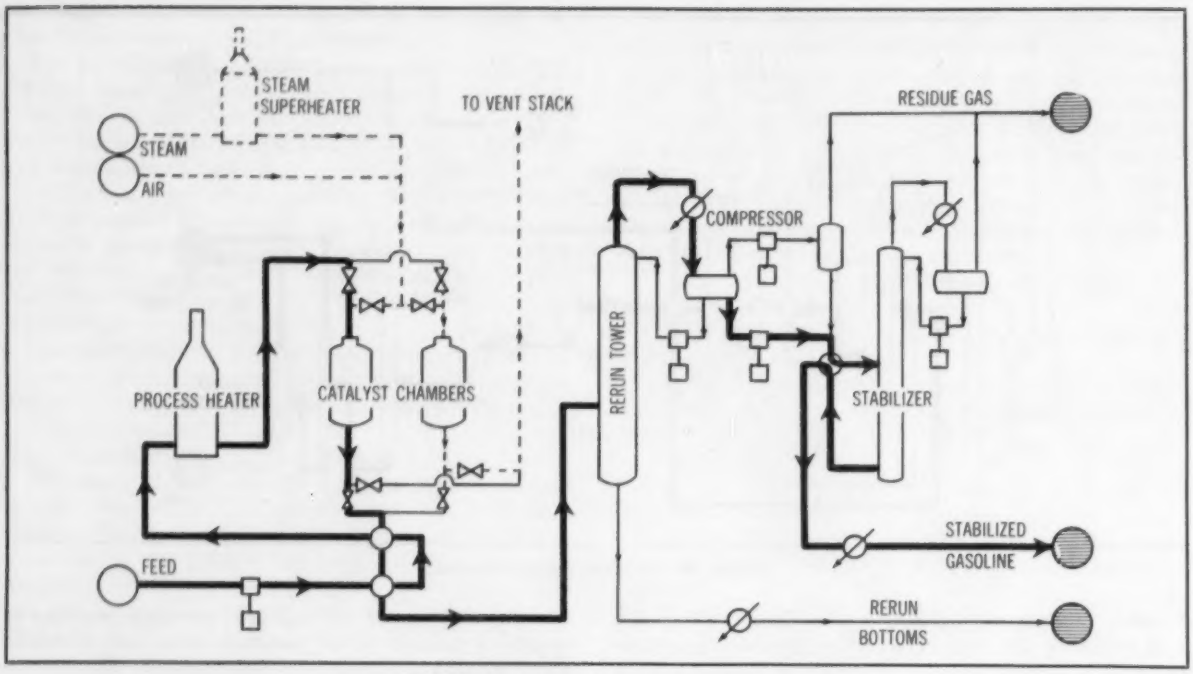


FIGURE 25—Cycloversion catalytic reforming.

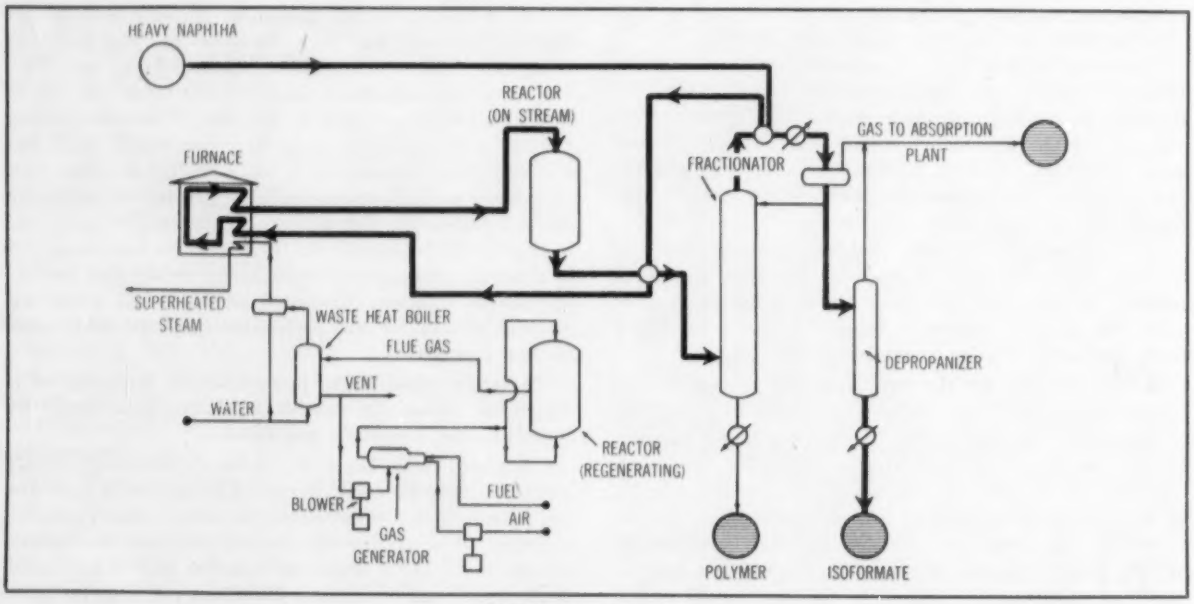


FIGURE 26—Isoforming.

Since the kiln in the TCR unit design is operated at essentially atmospheric pressure, and the reactor is operated at 150-200 psi, a lock chamber must be employed to get catalyst into and out of the reactor. The lock valves are controlled by a cycle timer as described by Payne, Evans, Bergstrom, and Bowles.[243] This, of course, reintroduces the complication of the cycle timer to the reforming operation whereas the design progression from hydroforming to fluid hydroforming had the elimination of the cycle timer as one of its advantages.

With Other Catalysts—Cycloversion—Cycloversion catalytic reforming is a fixed-bed process employing a naturally-occurring bauxite as a catalyst. It differs from all the other catalytic reforming processes described here (except Isoforming) in that no hydrogen recycle is employed. As pointed out by Edwards,[84] the term Cycloversion has been broadly applied to desulfurization, cracking, and reforming operations using this catalyst. Cycloversion catalytic reforming units can, in fact, be operated as desulfurizers or as reformer-desulfurizers.

The application of cycloversion catalytic reforming to small refineries has been outlined by Daniels and Conn.[69] The catalytic desulfurization and reforming of naphthas over bauxite catalysts in the Perco process has been

further discussed by Helmers and Brooner.[157] The operation of a Cycloversion reforming unit at the Peppers Refining Company in Oklahoma City has been described by Beebe.[33] A flow diagram of a Cycloversion reformer is shown in Figure 25.

Some of the mechanical features of the Cycloversion process have been discussed by Seed,[276] and reactor construction is described at length. Detailed valve specifications for Cycloversion units have been published by Rockwell Manufacturing Company.[266] A skid-mounted, 650-bpd Perco Cycloversion reforming unit has been described by Grebe, Miles and Seed.[115]

With Other Catalysts—Isoforming—The Isoforming process is a development of the Standard Oil Company (Indiana) and has been described briefly in the literature by Anon,[22] by Armistead,[27] and in patents by Thiele, Schmitkons, and Hull.[298, 299]

Feed stocks to Isoforming units are thermally cracked naphthas, preferably of high olefin content. This is in contrast to catalytic reforming in a hydrogen recycle atmosphere where cracked naphthas must be mixed with straight-run naphthas to prevent excessive hydrogen consumption. As pointed out above, Isoforming and Cycloversion are the only two of the catalytic reforming processes which do not use a hydrogen recycle, so the limitation on unsaturated feed stocks does not apply to these processes.

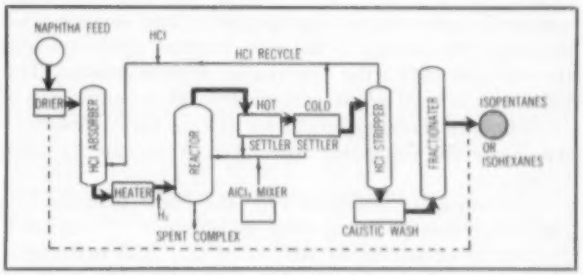


FIGURE 27—Pentane-hexane isomerization.

As pointed out in the over-all process comparison in Table 4, Isoforming is a very low-pressure process. Only moderate octane number improvement is obtained but liquid yields are high.

Operating costs for Isoforming have been presented by Read.[265] A flow diagram of the Isoforming process is presented in Figure 26.

Consider Also Isomerization . . .

Isomerization can perhaps be considered as the only true reforming reaction since all the other catalytic reforming reactions (hydrocracking, dehydrogenation, desulfurization) split molecules into fragments rather than re-forming them as isomerization does.

As pointed out by Evering,[91] isomerization becomes more important as catalytic reforming causes gasolines to become more aromatic. To permit full use to be made of tetraethyllead (which is less effective with aromatics than with paraffins), high-octane paraffins must be incorporated in gasoline blends. Such high octane paraffins can only be obtained from alkylation (which may require butane isomerization) or from the isomerization of pentanes or light naphtha cuts. Aside from the point of more efficient TEL utilization, isomerization is the best way to raise the octane number of pentanes and hexanes without yield loss; such hydrocarbons do not lend themselves to cyclization and conversion to high-octane aromatics in reforming processes.

As discussed earlier, isomerization of both paraffins and naphthenes constitutes one of the key reactions over reforming catalysts. In this connection, in recent discussions of both Platforming and Catforming by Haensel and Walter[141] and by Fowle, Bent, and Milner,[101] respectively, the isomerization of pentanes and hexanes in platinum reforming has been given particular emphasis. Fowle, Bent, and Milner point out that a simple, low-pressure, single-reactor Catforming unit will give extensive conversion of normal pentane to isopentane with very low yield loss.

As shown in Figure 6, the Research octane numbers of equilibrium mixtures of paraffin hydrocarbons are not too favorable, a C_7 fraction having a RON of only 50. However, a C_5 fraction has an octane number of 85 as compared with a Research rating of 61.7 for normal pentane. Further, isomerization improves motor octane number along with research octane numbers to a greater extent than other refinery processes, with the exception of alkylation (which also produces branched chains, but by other means).

Thus, it would seem likely that isomerization of light naphthas might well be a logical contribution to present-day octane improvement problems.

As reviewed by Evering[91] and by Gunness,[121] there have been commercial applications of pentane isomerization by Shell and by Standard Oil Company (Indiana). The only commercial operation of light naphtha isomerization has been the Isomate process of Standard Oil Company (Indiana). Of course, butane isomerization has been widely practiced for the preparation of alkylation unit feed but such an operation is not pertinent to the topic of octane improvement techniques. Some of the fundamentals of isomerization have been discussed by Finger.[96]

The Isomate process was described by Swearingen, Geckler, and Nysewander.[295] It converts normal pentanes and hexanes to isopentanes and isohexanes over an aluminum chloride catalyst in a liquid-phase operation carried out at 800-900 psi and at a temperature of 250 F. A flow diagram for pentane and hexane isomerization is shown in Figure 27.

As described by Evering, Weems, and Fragen,[92] an Isomate plant charging 5000 bpd of light naphtha has been operated at the Whiting refinery of Standard Oil Company (Indiana). A second isomerization plant at the Salt Lake City refinery of Utah Oil Refining Company charges 1750 bpd of light naphtha. Whereas the Whiting plant operation is described as once-through on hexanes and recycling on pentanes, the Salt Lake City plant op-

eration is once-through on pentanes and recycling on hexanes. The former is the true Isomate operation and the latter is called the Indiana neohexane process. The third commercial plant described by these authors is a 1620 bpd isopentane unit at the Texas City refinery of American Oil Company (then Pan American Refining Company).

A commercial installation of the Shell pentane isomerization process is described by Galstaun.[108] The Shell process, according to McAllister et al.[212] has two major operating features which distinguish it from the Indiana process. One is the Shell catalyst which consists of aluminum chloride dissolved in antimony trichloride, as compared to the aluminum chloride-hydrocarbon complex used in the Indiana process. The other is the use of hydrogen as an inhibitor for cracking reactions in the Shell process as distinguished from the addition of 0.5 percent benzene in the Indiana process for this same purpose.

In addition to the processes described above which have been commercialized, other pentane and light naphtha isomerization processes have been developed by various organizations. One such process, described by Perry,[244] has been developed cooperatively by Anglo-Iranian Oil Company and Standard Oil Development Company. It employs a solid catalyst consisting of aluminum chloride adsorbed on bauxite and utilizes introduction of fresh $AlCl_3$ along with the feed to maintain catalyst activity.

Whether further commercial units for pentane and hexane isomerization will employ aluminum chloride or platinum (or other) catalysts remains to be seen, but isomerization of light naphthas does look promising as the next octane improvement step.

Dollars and Cents of Octane Improvement . . .

Economic analyses occasioned by the high-cost operations engaged in by refiners in meeting product demands of World War II did a great deal toward advancing refiners' understanding of the economics of octane number improvement. The now generally-used approach of alternate-use economics was developed to a large degree in connection with defense contracts calling for abnormal operations in order to maximize production of aviation gasoline components, synthetic rubber raw materials, and petrochemicals. Most such abnormal operations occasioned certain components to be withdrawn from the motor-fuel pool of a given refinery, and it was therefore necessary to develop calculation techniques for putting an economic significance to attendant effects on gasoline quality, principally on octane number, that stemmed from operations changes. Many changes, though large as measured by the effect on supply of critical products, were incremental in nature with respect to effects on gasoline quality, for instance, and the concepts of incremental octane number improvement techniques were therefore developed and studied.

Economic analysis in petroleum refining is not a straightforward problem. Youngs[324] made this statement in a 1949 article: "There is general agreement in the petroleum industry that the determination of unit cost of the hundreds of products produced from crude oil is a problem not yet solved satisfactorily." Youngs went further to state that Esso Standard Oil Company uses the so-called replacement concept as a procedure for operational analysis accounting. Allocating total refinery costs among the many products on the basis of current realizations was noted to be not acceptable to management for purposes of planning or review. Such a method gives the same profit margin to each product, and market price changes can affect costs when actually no change has occurred. In the replacement cost method technical personnel compute unit product costs based on plant operating costs broken down by units and operating data such as crude runs, yields, fuel prices, etc. The replacement cost theory is predicated on processing crude oil to ultimate yield of only three products: gasoline, fuel gas, and fuel oil. The cost of the gasoline equals crude cost plus operating expenses minus credits for the fuels. Costs of intermediate products are then computed as the cost of processing an additional amount of crude to *replace* the gasoline lost by not processing such intermediate products to ultimate yield. Such costs indicate on a long-term basis the cost of producing more or less of a particular product as compared with its equivalent in terms of gasoline, fuel gas, and fuel oil.

Economic analysis in petroleum refining has been defined as the application of the dollar sign to such refinery factors as raw material costs, product prices, manpower (operating and maintenance), warehouse operation, optimum rates and yields, utilities, original investment, depreciation, and reasonable "pay-out."

An excellent discussion of economic analysis in petroleum refining has been presented by Hamilton.[142] As pointed out by Hamilton, one of the analyst's basic tools is operating cost. Operating cost of a refinery unit is subject to division into two component parts: direct (or controllable) costs, and overhead items. The direct (or controllable) costs are those incurred when starting up or shutting down an existing unit and include operating labor, direct supervision, maintenance and repair labor and materials, chemicals, fuel, utilities, auxiliary services, royalties, and employee benefits. Overhead items include depreciation, taxes, insurance, and administrative expense. Total operating cost is the sum of direct and overhead items. Marginal operating costs (composed primarily of certain elements of direct cost) are those sustained when increasing the charge rate to an operating unit. Direct costs can be estimated by taking 50 percent of total operating cost, and marginal costs are in turn about 50 percent of direct costs for refining equipment.

Economics of octane improvement requires an understanding of operating costs, particularly when incremental costs are under consideration. Incremental octane improvement is that obtained by changing an existing operation in the refinery in order to improve gasoline octane number.

The problem of allocating operating cost and profit to the many refinery products was also illustrated by Hamilton.[142] Six different approaches to allocating costs were given, and the replacement cost concept was further clarified.

Since World War II, the problem of improving octane number by refining methods and the attendant economics have received the attention of several industry spokesmen. Thus, general economics of octane improvement was the topic discussed by Holaday.[168] Relating wartime investment to the increase of three octane numbers between 1941 and 1946, an industry octane number was speculated to cost $300 million. Most of the investment had been in catalytic cracking, however, and the increase in gasoline yield should perhaps be allocated a significant share of the investment. A plot of pool octane number (Research octane number at 1.0 ml TEL) versus total investment for a 100,000 bpd B/D refinery was also presented. The plot is summarized in Table 12.

TABLE 12—Octane Number Vs. Total Investment

$, Millions	RON, 1.0 ml TEL	Operation
17	70	Straight Run
23	74	Thermal Cracking
26	82	Thermal Reforming
28	83	Catalytic Polymerization
65	92	Catalytic Cracking and Alkylation
90	97	All Cracking Catalytic and Reforming All Straight Run

Considering a basic refinery to contain only thermal cracking and thermal reforming as conversion processes, Parker[241] has presented an octane-yield evolution based on incorporating post-war processing as shown in Table 2.

Draeger et al.[79] have set forth three important methods of increasing yield and quality of gasoline: (1) thermal or catalytic cracking of materials boiling above the gasoline boiling range, (2) the condensation, polymerization or alkylation of compounds lower boiling than gasoline, and (3) structural alteration of compounds within the gasoline boiling range. An illustrative example of the cumulative effect of sequential addition of selected processing in producing high octane number motor gasoline from an average crude is shown in Table 3.

Diversion of heavy gasoline fractions for octane improvement has been practiced to some extent ever since antiknock quality first became a motor fuel specification. The economics of end point reduction for octane improvement are determined by three factors: the relationship between the quality of the heavy fraction and that of the pool gasoline of which it would normally be a part, the alternate use value of the heavy fraction, and the effect on gasoline butane content occasioned by the diversion. Since quantities of middle-distillate fuels are generally fixed as far as marketability is concerned, a diversion of heavy naphtha from gasoline would normally occasion an increase in cracking stock or heavy fuel oil. The normal value of either is such that heavy naphtha diversion is not generally economic for octane improvement considerations alone. If, on the other hand, diversion of heavy fractions is accompanied by an expanded market for a distillate fuel, such as jet fuel, the differential price will determine the extent to which octane number can be improved by such a means while not exceeding improvement costs by other methods.

Holaday and Happel[169] discussed end point reduction in connection with a review of antiknock quality control in the refinery. Motor octane numbers (MON with 3.0 ml TEL) of narrow boiling fractions of straight run and thermally cracked naphthas from a Mid-Continent crude were given as shown in Table A.

TABLE A

STRAIGHTRUN		THERMAL	
Range, °F.	MON, 3.0	Range, °F.	MON, 3.0
87–266	86	91–229	92
140–280	80	188–277	83
250–322	75	234–324	77
314–396	68	300–387	71

Even the heaviest fractions of catalytically cracked naphthas are too high in quality to permit improvement to any appreciable degree by end point reduction. The same holds true for catalytic reformates, the heavy fractions high in aromatics having higher octane numbers than the light fractions in some cases.

Data on the effect of end point on octane number for straight-run naphthas have been presented by Read.[256] For a wide variety of crudes, data are given for end point versus Motor octane number (clear and with 3.0 ml TEL), yield, and Reid vapor pressure. Reducing end point on a Mid-Continent naphtha to 270 F. was shown to improve MON (3.0 ml TEL) from 71 to 81 at the expense of about 50 percent yield on 400 F. naphtha.

The effect on octane quality of varying end points of various gasoline components has been studied by Offutt et al.[238] by fractionating naphthas using about 15 theoretical plates. Blending Motor octane numbers (clear) of heavy incremental fractions of the various gasolines are summarized as shown in Table B.

TABLE B

	MON, Clear, Blending Value				
	Vol. Percent of 10 RVP, 400° F., E.P.				
COMPONENT	100	25	20	15	10
Catalytically Cracked	77	78	76	75	71
Polyformed	76	76	75	75	75
Thermally Cracked	67	65	63	60	57
Straightrun	52	43	41	38	36

Thermally cracked and straight-run naphthas would appear to offer the best possibilities for pool octane improvement.

Three methods of improving gasoline octane number were discussed by Risk and Alspaugh[264] in 1951. Reducing the end point of gasoline components and thereby diverting low octane materials to less valuable products was one of the methods discussed. As pointed out in the paper, end point reduction allows only limited improvement within reasonable economic and volatility considerations. Table C shows typical data were given for straight-run and thermal naphthas.

TABLE C

STOCK	End Point, °F.	Yield, %	RON
Straightrun	390	100.0	54.6
	344	95.5	57.3
	326	80.3	59.0
Thermally Cracked	401	100.0	74.4
	392	96.1	74.8
	354	80.1	78.0

Leaded octane numbers do not increase to quite the same extent as clear octane numbers. When reducing end point to result in a 12.5 percent loss in 10-pound Rvp

How To Get Those Top Octanes

gasoline yield, it was shown that the degree of improvement was essentially independent of whether straight-run or thermally cracked were reduced singly or whether both were reduced to a point where a 50/50 blend would decrease by 12.5 percent. At 3.0 ml TEL, the gain in RON was essentially linear at 1.7 RON for each 10 percent loss in blend yield.

Octane improvement economics is the tool for determining the optimum sequence of processing steps and the attendant optimum use of TEL. In a discussion of how engineering developments affect petroleum refining, Mount[222] has stated "the rising cost of refinery construction compared with the relatively firm price of TEL has made its use more and more economical and the trend is toward higher concentrations." Mount's study went further to give an engineering approach to the optimum percentages of premium and regular gasolines that a refiner should produce.

Can You Save With TEL?

The most important factor involved in the economics of the use of lead is lead susceptibility—the number of octane numbers gained for the addition of each milliliter of tetraethyllead. Variations in lead susceptibilities for different types of gasolines have been discussed by Holloway and Bonnel[179] and by Nelson.[230]

Octane response of gasolines to addition of tetraethyllead has been correlated by several techniques.[150, 89] The tetraethyllead chart in use at Ethyl Corporation Research Laboratories is based on a linear relationship between the logarithm of anti-knock quality (expressed as Performance Number) and the logarithm of TEL concentration. The conversion of octane number to performance number is expressed by the following equation:[163, 67]

$$PN = \frac{2800}{128\text{-}ON}$$

Ethyl investigators[162] have found the equation Log PN = m Log (T + 0.2) + b to best depict octane response data over the range of 0.5 to 6 ml per gallon where m and b are constants and T is TEL concentration. TEL response data on contemporary commercial gasolines have indicated that over the range of 0.5 to 5.0 ml per gallon TEL, the relationship Log PN = m Log (T + 0.5) + b does a good job of expressing octane response. This latter expression has been used to define the TEL response of commercial gasolines as currently produced in the refining industry.

The Gasoline Testing division of Ethyl Corporation periodically obtains TEL susceptibility data on refinery samples of premium and regular gasolines. The data represent about 70 percent of the domestic refining capacity, and company gallonage sales reports permit combining individual premium and regular gasoline combinations into a blend representing each refinery's gasoline pool, i.e., the composite of all the gasoline blending components from which the various grades are blended and marketed. The constants m and b in the above equations have been determined for each refinery gasoline pool as defined by Fall 1954 data, and the weighted average constants are shown in the following equations:

Premium: Log PN = 0.125 Log (T + 0.5) + 1.862
Regular: Log PN = 0.161 Log (T + 0.5) + 1.765
Pool: Log PN = 0.151 Log (T + 0.5) + 1.795

These gasolines have properties shown in Table D.

TABLE D

	RON	TEL	RON, 1 ml	RON, 3 ml
Premium	94.4	2.5	91.4	95.1
Regular	86.8	2.1	82.9	88.7
Pool	89.3	2.2	85.6	90.8

The constant *m* might be used to represent TEL susceptibility since it is the slope of the straight line on log-log paper, and Table 13 gives the industry distribution of *m* as represented by the Fall, 1954 data.

At current high octane levels most refiners are using tetraethyllead in the concentration range of 2 to 3 ml per gallon. As a matter of fact, as of Fall, 1954, twenty-three percent of U. S. gasoline contained 2.75 ml per gallon TEL or more, and 68 percent contained as much as 2.0 ml per gallon. Under such conditions the rate at which refiners are paying for octane number of TEL addition is of more interest than the over-all cost of the octane improvement obtained at current usage levels.

The equation used above for TEL response provides a convenient means of measuring the rates at which refiners are currently buying octane improvement by TEL addition. Upon differentiation the equation gives $\frac{dT}{dRON} = \frac{(T + 0.5)\ (PN)}{2800\ m}$, which gives the rate of change of concentration (T) with respect to Research octane number (RON). Note that the RON term was obtained by conversion from performance number (PN). Units of the right side of the differential are ml per gallon per Research octane number. Converting to a petroleum industry barrel basis and inserting c to represent TEL cost in cents per milliliter, the following equation is obtained:

$C = \frac{42c\ (T + 0.5)\ (PN)}{2800\ m}$ where C is defined as incremental octane improvement cost expressed as cents per Research octane number per barrel (cents per RONB).

Such incremental cost has been calculated for each refinery gasoline pool on which TEL susceptibility data were obtained in Fall, 1954. Table 14 gives the distribution of the incremental costs. TEL cost basis was 0.22 cents per ml.

TABLE 13
Industry Distribution of *m* in Expression Log PN = m LOG (T + 0.5) + b

Percent at or Above	m
0	0.229
10	0.175
20	0.170
30	0.164
40	0.157
50	0.150
60	0.146
70	0.143
80	0.134
90	0.118
100	0.100

TABLE 14
Industry Distribution of Incremental Octane Costs As Attained Through TEL Addition

Percent Equal to or Above Indicated Cost*	¢/RONB
100	1.0
90	3.2
80	3.5
70	3.9
60	4.1
50	4.6
40	4.8
30	5.1
20	5.4
10	6.1
0	7.5

* Percentages derived from weighted system based on refinery crude capacities.

The national average gasoline pool, 89.3 RON at 2.2 ml per gallon TEL, reflects an incremental cost of 4.4 cents per RONB. The TEL susceptibility of the pool is such that leaded to 3.0 ml per gallon, the pool would be 90.8 RON, and at this concentration and quality, incremental cost would be 5.8 cents per RONB. Thus, considering the average gasoline pool, octane improvement is available by TEL addition at costs ranging from 4.4 to 5.8 cents per RONB. The tabular distribution indicates costs for specific refineries at current use levels to range from 1.0 to 7.5 cents per RONB.

Considering the average constants (m and b) for the premium and regular gasolines individually, one calculates incremental costs of 6.6 and 3.6 cents per RONB, respectively.

Because of the effect that sulfur compounds are known to have on TEL response, a brief discussion of sulfur effects and desulfurization is pertinent to octane improvement economics. The effect of sulfur, measured as TEL efficiency, is independent of TEL concentration. This has been concluded from the data of Birch and Stansfield,[46] the extensive work of Ryan,[271] and the works of Livingston.[194, 195, 196, 197] Furthermore, as reviewed by Livingston,[194] all sulfur compounds that have the same type of sulfur linkage have the same effect on TEL when compared at the same sulfur concentration.

Livingston[194] has extended work of Ryan[271] to give the equation: $\frac{L}{100 - L} = k\,c^n$ to describe the effect of sulfur on TEL response. In the equation, L is defined as loss of TEL efficiency equal to $\frac{Ao - a}{Ao} \times 100$, where Ao is actual TEL concentration and a is the TEL concentration in sulfur-free fuel that corresponds to the observed octane number. The term c is weight percent sulfur, and the constants k and n vary with sulfur type as shown in Table E.

TABLE E

SULFUR TYPE	k	n
Thiol	11.7	0.68
Disulfide	10.5	0.68
Sulfide	7.3	0.68
Thiophene	7.4	1.00

Pulleyblank and Lovell[251] and Mapstone[202] have also presented relationships between TEL efficiency and sulfur type and concentration.

From Ethyl survey data it is known that sulfur averages about 0.08 weight percent in the national average gasoline pool. The characteristics of this average gasoline have been given earlier in this section. It is interesting to speculate on the effect on octane improvement if all gasoline were completely desulfurized.

Using the relationships presented by Pulleyblank[251] and assuming sulfur concentration to be half monosulfide and half thiophene type, a concentration of 0.08 weight percent total sulfur is found to be equivalent in TEL effect to 0.026 weight percent disulfides which indicates a TEL efficiency of about 52 percent. This is equivalent to saying that complete desulfurization would increase national octane quality by 3.2 Research octane numbers at current TEL concentration. At a competitive cost of, say 5.0 cents per RONB, the complete desulfurization would have to be accomplished for a total cost of about 16 cents per barrel of total gasoline. The relationships between TEL efficiency and sulfur type concentration[251] are exponential in nature, and therefore partial desulfurization is not as rewarding. For example, 50 percent desulfurization would increase TEL efficiency to about 60 percent (RON increase of 0.8) and 80 percent desulfurization would increase TEL efficiency to 71 percent (RON increase of 1.6).

Desulfurization processes have been described fully in a recent symposium.[246] Because of the relationships between sulfur and TEL effectiveness, desulfurization of gasoline should continue to be an integral part of the refinery octane improvement program.

What Reforming Processes Give . . .

A refiner's octane improvement problem is defined once a basis is established for economic product distribution from the crude charged. Thus, refinery distillation and cracking equipment is operated to produce the desired quantities of gasoline, distillate fuels, heavy fuels, and specialty products. Each operation is conducted such that the combined quantities of products falling in the gasoline boiling range aggregate the approximate total gasoline requirement. Considering the specifications of the various grades of gasoline to be marketed permits a calculation of the light ends (butanes) that may be left in the gasoline pool when meeting volatility specifications.

TABLE 15—Typical Gasoline Pool

COMPONENT	Vol. Percent	RON—(Blending Values) Clear	3 ml TEL
Catalytically Cracked Naphtha, 400 EP	32	90	97
Straight Run, 400 EP	48	50	72
Catalytic Polymer	5	106	106
Thermal Naphtha	8	71	86
Butane	7	102	106
	100	71	85

At this point a refiner's gasoline pool may be illustrated by the typical balance shown in Table 15.

This refiner's pooled octane quality is only 71 Research before TEL addition. At this point the octane improvement problem is defined. The refiner has either to add TEL to the pool or withdraw certain components, improve their qualities by processing and return them, or a combination of the two. Since even maximum TEL gives an RON of only 85, some processing of gasoline components is needed in the illustration in order to reach the pool levels of 90 RON required today. Of course, in addition to considering average gasoline octane requirements, the problem of withdrawing certain component combinations that will blend to various grade qualities must also be weighed. At this point in the discussion this factor is not considered, however.

Operations conducted to arrive at a pool of components blending to 71 RON were defined not by octane

considerations, but by over-all product distribution requirements. Thus octane improvement is concerned with changing the octane quality of a pool or its predetermined components by processing or additive means.

Thermal Reforming Virgin Naphtha

Thermal reforming of virgin naphtha components of a gasoline pool affords a means of octane number improvement that has been in use by the industry since the 30's. The double effect of "withdrawing" a low octane component from the pool and returning in its stead a reformate that is 20-40 octane numbers higher enhances over-all gasoline octane number appreciably. The cost of the improvement is the value of the gasoline lost plus operating costs minus the by-product credits for light ends and heavier fractions, if any. Thermal reforming also affords a means of elevating a naphtha component normally in a distillate fuel to an octane quality that permits blending into gasoline. In such cases it is difficult in economic analysis to evaluate the operation strictly on the basis of pool quality improvement because the actual effect may be to lower pool quality. In this respect, thermal reforming is analogous to cracking which converts a heavy fuel to a lighter fuel of greater value.

In 1933, Le Roi and Ferguson[193] reported data on three years of plant scale thermal reforming of straight-run and cracked heavy naphthas. Data (expressed as percent degradation to gas and tar per point of octane improvement on distillate) were given as shown in Table 16 for a

TABLE 16—Results of Thermal Reforming

OCTANE NUMBER RANGE	PERCENT DEGRADATION PER UNIT OCTANE IMPROVEMENT		
	1	2	3
31 to 60	0.39	0.29	0.30
65 to 70	0.98	0.70	0.68
70 to 75	1.38	0.90	0.90
75 to 80	1.61	....	1.12

1. Recycle at 940 F., undercutting feed; 2. Recycle at 940 to 970 F.; 3. Once through 917 to 995 F.

230-415 F., 31 ON straight-run naphtha. Although no economics are shown, the percent degradation gives some measure of the cost of an octane number by this process.

In 1932, Goldtrap[112] observed that operating costs of thermal reforming ran 25 cents per barrel of fresh charge. He further stated, "As measured by previous standards, reforming is not a profitable operation." Reforming has thus been recognized for years as an operation conducted for quality improvement to which there must be assigned a definite cost.

In 1937, Gary and Adams[107] presented equations for calculating in a typical refinery the optimum combination of thermal reforming and TEL use to solve an octane improvement problem. The industry was making a transition from the Motor Method to the L-3 Method for octane number measurement[110] at the time, but the economic principles apply even today, despite the low octane levels then under consideration. The sample case presented by Gary and Adams showed that reforming of the heaviest 40 to 50 percent of the 100-400 F. virgin naphtha to a reformer yield of 85-90 percent of 100 percent butane recovery product was generally optimum. Also indicated in their work was the fact that the higher the market price of gasoline, the lower the percentage of total naphtha reformed should be. The authors further commented that the percentage yield for optimum reforming was substantially higher than used in most reforming operations, indicating that reforming in general should be less severe than commercially practiced. This observation might well apply to operations conducted today.

Read[259] pointed out in a postwar study of gasoline production from Pennsylvania crude that selection of the proper gasoline fraction to be reformed and the conversion level at which the reforming operation is to be carried out are the two important factors to be considered in gasoline operations. Yield-octane data on thermal reforming showed that it was more advantageous from the standpoint of over-all barrel octanes to process all the heavy naphtha available at an intermediate or low conversion level, rather than to process only a part of the same naphtha at a high conversion level.

Bogk, Ostergaard, and Smoley[53] have discussed the joint conversion of naphtha and hydrocarbon gases to produce a high yield of high quality motor fuel as discussed earlier under "Polyforming." They reported that in fully combining thermal reforming with thermal polymerization to effect both conversions wholly or partly in the same reaction zone, it was found possible to elevate octane levels and improve economic realizations materially. Economics of such operations are difficult to analyze because two objectives are being met: octane number is being improved, and fuel gas value light ends are being converted into the gasoline boiling range. The naphtha reforming itself is purely an octane improvement operation. Polymerization of the gases is a separate economic problem in many respects, since catalytic polymerization of the olefins offers a possible economic alternate. Extensive yield-octane data are given in the paper, and economics characteristic of 1940 are also discussed in detail.

Wagner[308] points out that thermal reforming a wide boiling range straight-run naphtha (250-400 F.) rather than a 300-400 F. cut would be calculated to be optimum on an unleased basis and neglecting operating costs. When reforming to a given leaded octane level on the total pool, however, a heavier fraction would be optimum. At maximum TEL levels a very heavy fraction (325-400 F.) might be advantageous.

A manner in which the most economical combination of thermal reforming and tetraethyllead may be determined and the effects of product prices and octane specifications on economics of reforming have been reviewed thoroughly by Feuchter.[95] A hypothetical refinery designed to illustrate these economics was shown to provide a small justification (1 cent per barrel of gasoline) for thermal reforming (combined with catalytic polymerization of the cracked gases) when charging a 275-400 F. fraction of virgin naphtha under mild conditions (Research octane number increase of 14 units) and when producing a gasoline pool of 84.0 RON. Pool octane level, gasoline price, TEL cost, and butane price each exerted a significant effect on the optimum reforming severity, defined in this work as octane number increase of the reformate, and the savings relative to no thermal reforming. An interesting observation in the Feuchter paper was the fact that with gasoline market price at 9.5 cents per gallon, there was little economic difference between reforming 300-400 F., 250-400 F., or 275-400 F. naphthas, nor was there appreciable difference over severity ranges

of 8 to 20 reformate octane number increase. This meant that it was possible to operate over a wide range of reforming severity and still be fairly close to the optimum. With higher gasoline prices, however, a relatively small change in severity results in a larger change in octane improvement costs. Of further interest in the relationships presented was the observation that the optimum severity for any given set of factors (gasoline price, octane level, etc.) varied little in terms of reformate octane increase but could vary widely in terms of dollars per day relative to no reforming. Extensive thermal reforming correlations are given in the paper to permit a refiner to determine the optimum reforming level for his own particular case.

McLaurin, McIntosh, and Kaufman[217] have reported some relative economics of thermal reforming in a comparison with hydroforming. Although hydroforming was found to possess a definite yield-octane advantage, when reforming to a given octane number pool, thermal reforming was found to be more economical below about 78 Motor octane number and hydroforming more economical above that level.

Thermal reforming is generally acknowledged to provide very economical octane number improvement under conditions where a very low octane straight-run naphtha can be withdrawn from gasoline and reformed under mild conditions. For example, considering the typical gasoline composition shown earlier in Table 15, if 33 percent of the straight-run naphtha (16 percent of total gasoline) is withdrawn as a 2.0-pound RVP, 40.0 Research octane number (clear) charge to a thermal reformer, the approximate result indicated by the correlations of Feuchter[95] would be as follows: for 600 psig operation and 10 weight percent dry gas production, 82.5 volume percent of butane free reformate of 3.7-pound RVP and 67.0 RON clear would be recovered. In addition, propylene, butylene, and butane yields would be 2.5, 2.0, and 3.0 weight percent of charge, respectively. The effect of such an operation on the gasoline pool octane number may be summarized by the simplified calculation shown in Table 17.

TABLE 17—Effect of Thermal Reforming on Gasoline Pool

	Percent Total Gasoline	RVP	RON, Clear	RON, 3 ml. TEL
Pool	100.0	10.0	71.0	85.0
Reformer Charge	—16.0	2.0	40.0	60.0
Reformate	+13.2	3.7	67.0	80.0
Butane	—7.5	70.0	102.0	106.0
Net	89.7			
Weighted Averages	.....	10.0	73.5	87.1

Thus thermal reforming would add 2.0 octane numbers (at 3.0 ml TEL per gallon) at the expense of 10.3 volume percent of total gasoline. Certain qualities were assumed to illustrate this effect. The correlations of Feuchter[95] indicate that as the octane number of the charge is increased (generally by widening the boiling range), the octane number of the reformate is also increased at a given dry gas yield, but the octane increase with respect to the charge is less. If the charge in the example had been 50 RON clear, for example, reformate qualities at 0.0 and 3.0 ml per gallon TEL would be 72.5 and 85 (approximately), respectively. Thus it may be seen that the effect of reforming a higher quality naphtha would be a lower pool octane increase at a given serverity. Polymerization of the olefins produced would increase the yield about 1.0 volume percent to 90.7 and would add 0.3 to 0.4 octane numbers to the resultant pool quality.

The economic balance required to determine the percentage of straight-run naphtha to be reformed and the corresponding yield-octane relationship to be attained when using tetraethyllead to maximum economic advantage was analyzed in detail by Keith, Carey, and Ward[184] in 1937. Also worked out were the economics of that day of using high octane, expensive blending agents from outside the refinery for octane improvement.

The problem of comparing thermal and catalytic reforming has been studied by Maples.[201] Correlations between Research and Motor octane numbers, clear and leaded, have been made for the major components of gasoline. Such correlations permit use of early data on thermal reforming when octanes were reported by the ASTM Motor method only.

Octane Improvement Costs in Catalytic Reforming

Making use of an arbitrarily defined unit of octane number improvement has been found to permit study of the problem on a consistent basis. The unit referred to is the Research octane number barrel (RONB) and is equal to barrels of gasoline of improved quality multiplied by the difference between the improved quality and the starting quality. Algebraically, this is stated $RONB = V(RON_2\text{-}RON_1)$, where V is product volume in barrels (42 gallons), RON_2 is the Research octane number of improved quality gasoline, and RON_1 is the original Research octane number. Attention is called to the difference between a unit so defined and a straight material balance of octane numbers. Once the RONB value is calculated for a given quality improvement operation, an economic analysis permits assigning a dollar effect to the improvement. The unit that gives small, convenient size numbers is cents per Research octane number barrel (cents per RONB).

Although yield-octane relationships comprise basic data for evaluating reforming processes, such data do not define (without considerable calculation) the improvement effects when reforming is added to a given refinery gasoline manufacturing operation. For this reason the unit cents per RONB will be used during the discussion of reforming techniques to follow. Use of such a unit does not imply an attempt to compare over-all costs of the many competitive means of octane improvement. Rather, the unit is considered to afford a common denominator for considering yield-octane economics as they might apply to specific operations. Of course, subject to assumptions that will be detailed, the use of cents per RONB does connote order-of-size costs for improvement techniques.

The effect of naphtha reforming on gasoline volume and quality may be described by the following calculation using 100 barrels per day as a basis:

Operation	Effect on Gasoline Pool, B/D	RON
Remove Low Octane Naphtha	-100	RON_S
Add Reformed Naphtha	$+Y$	RON_R
Net (Weighted Average)	$Y-100$	$\dfrac{Y(RON_R) - 100\ (RON_S)}{Y-100}$

How To Get Those Top Octanes

Volume percent yield of reformed naphtha is expressed as Y, Research octane number (at the given lead level) of the low-octane naphtha charge is RON_N and that of the reformate is RON_R (at that same lead level). By weighted averaging using volumetric blending Research octane qualities, the effective quality of the net effect (Y-100) on gasoline pool can be calculated as shown. Octane improvement imparted by such an operation to a gasoline pool in terms of RONB is equal to

$$(Y - 100)\left[\frac{Y(RON_R) - 100(RON_N)}{Y - 100} - RON_P\right]$$

where RON_P is the Research octane number of the pool (at basis TEL) before reforming. It will be noted that RONB is therefore independent of the volume of the gasoline pool on which a reforming effect is applied.

To afford a basis for calculating order of magnitude octane improvement costs from naphtha reforming yield-octane data in the literature, a general equation has been utilized:

$$¢/RONB = \frac{(Y - 100 - F)(P_g - 9.4T) + P_b(F + G) + P_f\,100\,H - 100\,E}{100\,RON_p - 100\,RON_n - 10F + Y\,(RON_r - RON_p)}$$

Where: Y = Yield of debutanized reformate, bbls/100 bbls of charge
P_g = Market price of gasoline of quality RON_p, ¢/barrel
T = TEL concentration, ml/gallon
P_b = Value of butanes, ¢/barrel
G = Yield of butane on reforming, bbls/100 bbls of charge.
P_f = Value of fuel gas, cents per million Btu
H = Yield of fuel gas (C_3 and lighter), million Btu/bbl of charge
E = Total Reformer Operating Cost, ¢/bbl of charge
RON = Research octane number at TEL concentration, T
Subscripts: p — gasoline pool before reforming effect
n — naphtha charge to reforming
r — debutanized reformate
F = bbls butane removed from gasoline pool to maintain 10 lb RVP per 100 bbls naphtha reformed. For simplification, butane RVP assumed to be 71 psi and butane RON to be 100 irrespective of T.

$$F = \frac{10\,(Y + 10\,RVP_n - 100) - Y\,(RVP_r)}{-61}$$

where RVP = blending Reid vapor pressure of component designated
TEL price basis = 0.214 ¢/ml

The equation was derived from a reforming-effect calculation of the type described above with the exception that a vapor pressure effect has been incorporated. The equation lends itself to naphtha reforming data reported on various bases. For example, if yields and qualities of reformates are expressed on a 10-pound RVP basis, then Y in the equation becomes volume percent 10-lb. reformate, the term (F+G) is changed to ($F—G_o$) where subscript o denotes barrels of outside butane required to reach 10-pound RVP on reformate per 100 barrels naphtha charge.

In order to be of use in interpreting naphtha reforming data found in the literature, certain assumptions have been made with respect to terms in the cents per RONB equation, and those are listed below:

P_g = 504 ¢/barrel (12.0 ¢/gallon)
P_b = 210 ¢/barrel (5.0 ¢/gallon)
P_f = 25 ¢/million Btu
E = 50 ¢/barrel
H = wt. % dry gas ÷ 9.4, 12.4, or 14.6 depending on whether the operation is mild, moderate, or severe
G = SCF/bbl charge times 0.00046, 0.00071, or 0.00109 depending on operation
RON_p = 90 at TEL concentration T

Most reformate quality data are given at two TEL concentrations, 0.0 and 3.0 ml per gallon. Therefore, in most interpretations, cents per RONB values will apply for pool TEL concentration of 3.0 ml/gallon. In cases where RON_n is not given on a leaded basis, correlations of Maples[201] have been used to obtain leaded qualities. In cases where leaded qualities of reformates are not given, Maples' correlations are used up to 100 RON at 3.0 ml per gallon, and a TEL response of 15 performance numbers ($RON = 128 - \frac{2800}{PN}$) for 3.0 ml TEL per gallon has been assumed for reformates reaching octane number levels above 100 with TEL. When not otherwise cited, blending RVP values for reformer charge stocks and debutanized reformates have been assumed to be 2.0 psi and 3.0 psi, respectively.

It can be appreciated that using a system so described does not permit—in fact prohibits—comparisons of different means of octane number improvement. The purpose in using an approach of this type is to put yield-octane effects on a consistent basis and to acquaint the reader with the general economics of octane number improvement.

Investment and Operating Costs—Reviewing the equation given previously for octane improvement cost,

$$¢/RONB = \frac{(Y - 100 - F)(P_g - 9.4T) + P_b\,(F + G) + P_f\,100\,H - 100\,E}{100\,RON_p - 100\,RON_n - 10F + Y\,(RON_r - RON_p)}$$

it will be noted that the cost unit is a function of three elements: yields of reformed gasoline and by-products, the respective octane qualities of the feed stock, the gasoline pool, and the reformate, and the operating cost factor E. The first two elements, yields and qualities, are to an extent fixed by circumstances or represent test data over a catalyst of known activity under specified operating conditions. The third element, operating cost, is then the cost of maintaining catalyst activity (both replacement costs and regeneration expense, if required) and of maintaining the specified operating conditions under the proper degree of control and safety. In addition, investment charges, taxes, insurance, royalty, and general administrative expenses (overhead) comprise part of the operating cost. On the premise that yields and qualities are normally set by a design basis, the most variable element of octane improvement cost may well be the operating cost item.

Knowledge of incremental yields and quality effects (varying charge rate and operating conditions) is very important to economic operation of a unit once it has been installed. Associated with such incremental product effects is also incremental operating cost, that part of total operating cost that varies as a function of charge rate and/or operating conditions. As discussed in an earlier section, the analysis of operating costs has been studied and reported by Hamilton,[142] who uses the term "marginal" rather than incremental.

It is recognized that prior to installation many factors go into management's decision to construct naphtha reforming units. As initially designed and built, the over-all cost may not be nearly optimum with respect to the immediate octane improvement problem. The unit may be oversize in anticipation of an octane improvement program stretching over a several-year period. Thus investment would be high when allocated to the immediate

octane improvement problem. Auxiliaries may also be out of proportion in anticipation of future demands. Decisions based on the economics of octane improvement may be divided into two distinct types—the decision to be made prior to constructing a unit, and the decision to be made after construction with respect to optimum operation of the facilities available. Long-term and short-term may be convenient terms for such decisions.

In demonstrating a short cut procedure for estimating plant cost, Gilmore[111] has used a catalytic reformer as an example. Gilmore's breakdown of a reformer's principal items that would normally be determined from a process flow sheet is given below:

Principal Items	
Vessels	$ 47,000
Heat Exchangers	101,000
Pumps	8,000
Compressor	45,000
Heater	59,000
Miscellaneous Mechanical	1,000
Instruments	17,000
Structures	3,000
Electrical Equipment	4,000
Freight	3,000
Total Principal Items	$288,000

Total other material (piping, concrete, insulation, painting, etc.) runs to $91,100, or 32.2 percent of total principal items. Other items of plant cost were total direct field labor, $75,000 (26 percent of total principal items), total indirect costs, $52,000 (18 percent of total principal items), and engineering, overhead, fee, and contingency, $116,000 (23 percent of total principal items). Total job cost was $688,000, or 199.2 percent of total principal items. Catalyst inventory was not included, nor was unit size referred to. Also pointed out in Gilmore's analysis are differences among major refinery process units with respect to the relationship that total principal items bear to total direct plus indirect cost.

Other interesting data on investment costs for catalytic reforming installations have been presented by the American Institute of Chemical Engineers in their 1954 Student Contest Problem.[2] This publication presents a breakdown of investment cost into two components—one independent of octane level, and one a function of octane level. The breakdown reflects the added costs of reactor volume, and catalyst inventory incident to operation under severe (high octane improvement) conditions.

A study of hydroforming economics published by McGrath[213] gives an economic balance sheet for a 7500 barrels per day Fluid Hydroformer operating on a 204-373 F. Mid-Continent naphtha of 39 RON, clear. With a 4.0 cents per gallon differential between 10-pound RVP gasoline and the feed stock and extraneous butanes at 5¾ cents per gallon, a payout time of one year on a $2.25 million investment was indicated before depreciation. A 10-pound RVP, 95 RON (3.0 ml TEL) product was made in 92 volume percent yield. Process cost was indicated to be 32.7 cents per barrel of charge exclusive of depreciation. Also pointed out in McGrath's study was the fact that regeneration facilities in fixed-bed hydroforming represent about 40 percent of the total investment.

Cost information (March, 1950, construction) on 10,000-bpsd moly catalyst hydroforming units has been given by Murphree[225] as follow:

	Fluid	Fixed-Bed
On Site Investment	$4,350,000	$7,370,000
Utilities	190,000	390,000
	$4,540,000	$7,760,000
Initial Catalyst Cost	$ 285,000	$ 560,000

The plants were designed to produce a C_4+ product of 95 RON, clear, from a mixed base naphtha.

An economic comparison between Fluid Hydroforming and thermal reforming plus polymerization has been given by Shepardson, et al.[278] The example is that of reforming 10,000 bpsd of 50 RON (clear) 200-350 F. virgin naphtha to produce a 91.5 RON clear, 10-pound RVP gasoline. Hydroforming was at a 90 RON (clear) level on the C_5 to 430 F. naphtha. Although hydroforming investment was $1,580,000 higher (4.9 vs. $3.32 million) and operating cost was 39.3 vs 29.5 cents per barrel of charge, a 63 percent per year return before income taxes was indicated on the differential investment. Shepardson further reported that reforming at a 95 RON (clear) C_5 to 430 F. product level for motor gasoline was favored by economics. Although unit investment for a 95 RON operation is higher, less capacity is required to make a given RON pool requirement. Economics were given comparing the hydroforming of 10,000 bpsd to 90 RON, clear, vs. hydroforming 8150 (1850 bpsd bypassed) bpsd to 95 RON, clear, to produce a 10-pound RVP, 91.5 RON clear gasoline. Investments were $4.9 and $4.52 million, respectively, and operating costs were 39.3 vs. 44.0 cents per barrel. A net credit of $550 per day was indicated for the severe case.

The major equipment requirements for a Fluid Hydroformer of 22,200-bpsd capacity has been given by Tyson[103] as shown in Table 18.

TABLE 18—Fluid Hydroforming Unit Requirements (Capacity—22,200 BPSD)

Equipment Requirements:	
Compressors, BHP	
Air	3,000
Recycle	2,400
	5,500
Heat absorbed, Furnaces, 10^6 Btu./hr.	125
Heat Transfer Surface, ft.^{2}	50,000
Reactor Steel, lbs.	620,000
Utility Requirements:	
Power, kw	4,900
Cooling water, gpm	5,900
Steam, net, lb./hr.	—1,500

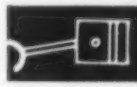
Pertinent to the first Fluid Hydroformer at the Destrehan, La., refinery of Pan-Am Southern Corporation, Seebold et al.[275] summarized operating cost data for operations producing hydroformate of 95 and 85 RON, clear, respectively, as shown in Table F.

TABLE F

RON, Clear	95	85
Charge, bpsd	2,000	2,750
Cents/Barrel of Charge:		
Utilities	15	12
Catalyst	5	4
Labor	8	6
Maintenance, Miscellaneous	12	8
Total	40	30

The high severity operating costs are noted to be 30 percent higher than those for the low severity operation.

Berg[36] has given projected utility requirement for a



How To Get Those Top Octanes

10,000-bpd Hyperforming unit as follows:

Fuel gas, Mm Btu/hr.	77.8
Steam, 400 psig, lb./hr.	6470
Cooling water circulation, gpm	3292
Electricity, kw	50

Also reported by Berg[38] have been capital investment costs of 150-300 dollars per barrel daily capacity and an initial catalyst cost of $20 per barrel of capacity for the Hyperforming process. Utility requirements for the first commercial Hyperformer (1100-bpd) were given as follows:

Fuel gas, M Btu/hr.	
Produced by unit	18,400
Required for heaters	11, 350
Net (production)	7,050
Air, scf/M	45
Cooling water, gpm (38 F. rise)	263
Power, kw	117
Catalyst makeup, lb./SD	9.0

Direct operating cost was indicated to be 17.7 cents per barrel of charge.

Nelson[231] has correlated Platforming unit costs by a log-log relationship between capacity, bpd, and investments adjusted to a 1946 construction index.

Investment costs (1950 basis) of $700,000 for a 1500-bpsd unit and $1,600,000 for a 5000-bpsd Platforming unit were cited by Haensel.[123] A 10,000-bpsd unit was stated to cost about $2.5 million. Also given were operating costs for a 1500 to 2000-bpsd unit as follows:

Item	¢/Barrel of Charge
Labor	4- 5
Maintenance	3- 5
Taxes and insurance	4- 5
Utilities, ex. fuel	4- 5
Catalyst, less than	10
Royalty	7
Total	30-37

Fowle et al.[102] reported Catforming unit construction costs for a size range of 750 to 12,000-bpsd to be $350 to $450 per barrel per day (1952 basis). Utilities for a 10,000-bpsd unit were also given as follows:

Reactor furnaces—delivered duty	57 Mm Btu/hr.
Stabilizer reboiler, 400 lb. steam	18,000 lb./hr.
Recycle gas compression	1,650 bhp
Power	450 kw
Cooling water make-up	175 gpm

Investments included hydrogen sulfide removal equipment. Catalyst replacement rate was stated to range from 40 to 100 barrels of charge per pound.

Estimated yields and costs for 500 and 4500-bpd Platformers operating on Mid-Continent naphtha have also been given by Anon.[23]

Teter et al.[297] in discussing operations with the Sinclair-Baker catalyst, state that catalyst cost will vary from 3 to 10 cents per barrel of reformate. A breakdown of total, typical operating cost was given as follows:

Item	¢/barrel
Operating labor	1.5
Supervision	0.1
Repair labor	5.3
Repair material	3.5
Payroll burden	1.4
Supplies, misc.	0.3
Utilities, Steam	5.1
Power	0.6
Water	1.3
Fuel	1.8
Total direct, ex. catalyst	20.9

Weinert et al.[320] presented typical utility requirements and average operating costs for a 1500-bpd Platformer:

Steam for small pumps, lb. per hour	650
Power, kilowatts	240
Fuel gas, millions of Btu/hr.	25
Cooling water, gpm	825
Costs:	
Labor, operating	4.6 ¢/bbl charge
Utilities	6.6
Catalyst	7.0
Laboratory	0.4
Royalty	7.5
Maintenance	4.3
Taxes, insurance	3.6
Total	34.0

Fulton[105] in a report on the potentialities of Platforming natural gasoline cited utilities for a 1500-bpd unit as follows:

Steam, lb./hr.	650 to	800
Cooling water, gpm	700	900
Power, kw hours	220	275
Instrument air, cfm	35	45
Fuel gas (1290 Btu) cfm	19,250	25,100

In discussing factors in selecting a reforming process, Steel et al.[289] commented that non-regenerative processes have lower operating costs because of simpler equipment. Regenerative platinum has the highest operating cost of the three types (regenerative platinum, non-regenerative platinum, fluid molybdena). Utilities costs vary little, and non-regenerative platinum has lower maintenance costs. With regard to investment, non-regenerative is lowest, and investment is 10 to 25 percent higher for regenerative platinum. Equipment cost is highest for fluid molybdena units, but percentage difference is lower for larger units. Non-regenerative platinum often requires auxiliary equipment for feed preparation and desulfurization. Initial catalyst inventory can be quite a factor, platinum catalysts ranging from $8 to $14 per pound and moly catalysts about 60 cents per pound, as indicated in Table 4.

Another important aspect of catalytic reforming costs is the question of licensing arrangements, as pointed out by Egloff.[86] Frequently the only method of obtaining process know-how is by licensing or paying a royalty rate. Such costs are normally only a fraction of the research and development costs that would be incurred in developing such know-how. Royalty is often a flat rate or a composite of a flat rate and a percentage of the product price. In the various platinum catalyst processes, the royalty picture is closely tied in with the questions of initial catalyst cost and catalyst replacement cost.

Paid-up royalty rates on the various catalytic reforming processes run in the general range of $100 per bpd of installed capacity. Running royalty rates (payment on the installment plan, so to speak) might run on the order of 7 cents per barrel. Egloff states that fixed-bed hydroforming royalty rates were set at 5½ cents per barrel of fresh charge plus 5 cents per barrel of aviation product plus 3 percent of the f.o.b. refinery bulk price of other special liquid products produced.

In connection with the general topic of investment and operating costs, it is worthwhile to mention two excellent bibliographies on "Investment & Operating Costs for Chemical and Petroleum Plants" as authored by Barnet[30] and by Harton and Tisot.[147]

Yield-Octane Economics—As previously pointed out, the yield-octane relationship particular to a given catalyst and set of operating conditions is one of the three important elements of octane-improvement cost. A second element is the relationship between qualities of the gasoline pool and both the naphtha charge and reformate. In the section which follows, the equation developed above for octane improvement cost will be applied to reported yield-octane data in order to afford a consistent basis for expression of costs as they might relate to a typical refinery octane improvement problem. As already outlined, this is accomplished by assuming a typical refinery gasoline pool quality and by assuming the third element of improvement cost (operating cost factor) to be a constant for all the catalytic reforming situations considered.

The data shown in Table 19 have been presented by Draeger et al.[79] and can be interpreted to give some basic insight into the economic aspects of octane improvement by catalytic reforming.

TABLE 19—Yield-Octane Relationships in Reforming Reactions

REACTANT	RON	Product	RON	Vol. Percent Yield, Theoretical
Cyclohexane	110	Benzene	99	82.3
Methylcyclohexane	104	Toluene	124	83.4
Trans-1, 3 Dimethylcyclohexane	85	Xylene	145	84.2
N-heptane	0	Toluene	124	72.7

Assuming no vapor pressure effect and neglecting hydrogen credit, application of the equation for cents per RONB to the theoretical yields above gives the following costs for methylcyclohexane, trans-1, 3 dimethylcyclohexane, and n-heptane, respectively: 9.3, 2.6, and 1.6 cents per RONB. Although the yield on n-heptane is lower, its octane number relative to that of the pool is so much lower than the other reactants that RONB is greater and unit cost therefore smaller.

Maples[201] reported that catalytic reforming processes employing a hydrogen-rich recycle gas stream gave good correlations of yield-octane data. Such correlations, however, assumed that the rate of decrease of yield of gasoline per unit increase in octane number was a function solely of the octane level at which reforming takes place. In checking the assumptions, correlations useful in general studies were obtained by plotting the instantaneous rate of disappearance of liquid product per unit increase in octane number of the reformate versus leaded octane number of the reformate.

The market price value of a Research octane number is a difficult if not impossible number to define. Nelson[232] has correlated average cargo prices of gasolines with the logarithm of specified Research octane number for the years 1947 to 1955. Such correlations indicated the relationship, cents per Research octane number per barrel to be 4.0, 5.9, 8.9, and 14.3 cents per RONB for octane numbers of 82.5, 87.5, 92.0, and 95.0, respectively. With unlimited flexibility to vary grade productions, a refiner could possibly take advantage of such relationships to tailor octane improvement steps to precise, optimum costs.

Yield Octane Economics—Moly Catalysts—Estimates by Parker[241] in 1945 shows a direct operating cost plus 20 percent depreciation of 1.6 cents per gallon of hydroformed gasoline. With low-sulfur virgin naphtha worth 5.0 cents per gallon and by-products at 1945 prices, cost of hydroformate was shown to be 7.7 cents per gallon (relative to 79 RON motor fuel at 6.0 cents per gallon) in a 5000-bpd unit. Thus 1945 economics showed this naphtha reforming operation to be economically unattractive. The cost would have to be assessed to octane number improvement.

Draeger et al.[79] state that in hydroforming a 250-300 F. naphtha is a more desirable feed than the corresponding 200-300 F. fraction because the higher boiling fractions of lower starting octane level show greater octane improvement. Reference to the cents per RONB equation will show that the relationship between the quality of the charge stock and that of the gasoline pool from which it is removed is a major factor in octane improvement economics. Thus, other considerations notwithstanding, the lower the quality of feed stock, the cheaper the unit improvement.

Catalytic reforming data on commercial runs on Mid-Continent naphthas alone and mixed with West Texas naphthas are given by Hill, Vincent, and Everett.[165] Extensive data on 19 commercial runs of hydroforming are available with which the cents per RONB equation can be utilized.

Scebold et al.[275] reported data for the first commercial fluid hydroformer installed at the Destrehan, Louisiana, refinery of Pan-Am Southern Corporation as shown in Table 20. Design feed stock had a boiling range of 220-335 F. and RON, clear, of 60.0. By changing severity, an incremental cost of 13.2 cents per RONB is indicated by the calculation.

TABLE 20—Yield Octane Data-Fluid Hydroforming

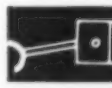
	Case 1	Case 2
RON, clear, 10 lb. Rvp, 400 F. product	95	85
Naphtha feed, BPSD	2,000	2,750
10 lb. gasoline yield, vol. percent	87.2	101
Extraneous C_4, vol. percent	3.2	10
Dry gas, wt. percent	12.2	6.1
RON, 10 lb. Rvp, 3 ml TEL	101	96
MON, 10 lb. Rvp, 3 ml TEL	90	85
Calculated ¢/RONB	6.2	4.8

Ferrell, Tusson, and Parker,[94] in reporting on the operation of a Fluid Hydroforming unit at Destrehan, La., gave general test data as shown in Table 21. Fluid catalyst make-up was noted to be 110 to 120 pound per day (0.06 pounds per barrel) as compared with a stated economic maximum rate of 0.2 pounds per barrel of feed.

TABLE 21—Yield Octane Data—Destrehan Fluid Hydroformer

Design feed rate, BPSD	2,000	
Charge, Rvp, psi	1.0	
RON, clear	50.0	
IBP-FBP, °F.	180-371	
Percent Naphthenes	35	
C_5 + Reformate, RON, clear	84	96 (extremes)
Yield, vol. percent	85.7	74.5
Butanes, vol. percent	5	7

Pilot Hyperforming data on a charge of 63 RON (+3 ml TEL), 27 percent naphthenes, and 19 percent aromatics has been given by Berg[36] as shown in Table



How To Get Those Top Octanes

22. No data on vapor pressure increase of the reformate were given, and calculation of cents per RONB by the illustrative equation is therefore obviated. Also given

TABLE 22—Yield-Octane Data-Hyperforming

RUN	A	B	C	D
C_5 + reformate, vol. percent	93.9	92.1	91.0	88.4
RON, 3 ml TEL	94.9	98.0	100.0	101.7
Dry Gas, Scf/Bbl.	300	391	396	423
Butanes, vol. percent	4.6	6.0	....	8.3

was a material balance for a 10,000-bpsd unit charging 70 percent Santa Maria cracked gasoline and 30 percent straight-run naphtha.

In a separate reference Berg[37] has also documented pilot Hyperforming data on a stock containing only 11 percent naphthenes as shown in Table 23. By making

TABLE 23—Yield Octane Data—Hyperforming Paraffinic Naphtha

CHARGE	
RON, 3.0 ml TEL	72
Percent Naphthenes	11
Percent Aromatics	9
IBP-FBP, °F	100-350

RUN	A	B	C
C_5^+ reformate, vol. percent	95.2	90.2	88.3
RON, 3.0 ml TEL	93.6	100.0	102.0
Dry gas, Scf/Bbl.	288	481	577
Butanes, vol. percent	5.1	8.3	10.2

assumptions with regard to the reformate vapor pressure increase in the Berg data, one could approximate cents per RONB for catalytically reforming such stocks.

Data on the first commercial application of Hyperforming as reported by Berg[38] are summarized below and cents per RONB has been calculated assuming dry gas yield of 400 scf per barrel.

Charge Stock	
IBP-FBP, °F.	241-418
RON, 3.0 ml TEL	73
Yield-Octane	
10-lb. RVP Reformate, Vol. %	104.4
Outside C_4 required, vol. %	9.0
RON, 3.0 ml TEL, 10-lb.	93.7
Calculated cents per RONB	*4.0*

Yield-Octane Economics—Platinum Catalysts—Haensel and Sterba[140] have made a detailed comparison between thermal reforming and Platforming of a Pennsylvania straight-run gasoline. Yield-octane relationships are shown. Other comparisons given are TEL susceptibilities, volatility characteristics, and hydrocarbon type and distributions. Summarized yield-octane data on the Pennsylvania naphtha for two operating severities are as shown in Table G.

TABLE G

	Charge	C_5 + Reformate	
RVP, psi	.31	5.6	6.3
Yield, Volume Percent	100.0	84.9	78.4
RON, 3.0	65.2	93.4	97.2
C_4, Volume Percent	....	7.9	11.4
Dry Gas, Weight Percent	....	7.4	10.7
Calculated Cents per RONB	....	4.0	4.5

The incremental octane improvement cost sustained by going to the lower yield is calculated to be 9.5 cents per RONB.

A detailed description of the first Platformer at Old Dutch Refining Company, Muskegon, Mich., is given by Kastens and Sutherland.[182] Also given are performance data as follows:

Charge		Platformate	
RVP	2.0	10-lb. RVP, Vol. %	97.1
% Naph.	33.0	X's C_4 required, vol. %	4.5
% Arom.	5.0	RON, 3.0, 10 lb.	94.7
RON, 3.0	70.2	C_3 and Ltr., SCF/bbl.	599
Calculated cents per RONB			*4.4*

Pilot data on Houdriforming different naphthas are given by Heinemann, Schall, and Stevenson[155] as shown in Table 24. Houdriforming pilot data on an East Texas

TABLE 24—Yield Octane Data—Pilot Houdriforming

	A	B	C
Charge:			
RON, 3.0 ml TEL	76.3	65.8	68.8
RVP, psi	0.7	0.7	....
Percent Naphthenes	42	43	52
Percent Aromatics	14	12	14
Products:			
C_5^+, vol. percent	85.8	84.3	86.6
C_4, vol. percent	5.2	7.2	6.1
RVP, psi	2.4	2.7	3.0
RON, 3.0 ml TEL	97.1	97.4	97.4
Dry gas, wt. percent	6.8	7.6	6.1
Calculated ¢/RONB	5.1	3.4	3.6

type naphtha are also available in an earlier work by Kirkbride.[188]

Processing a West Texas sweet mixed-base naphtha at 275 psig in a pilot plant Houdriformer was discussed by Dart et al.[73] The data in Table 25 reflect severity

TABLE 25—Pilot Houdriforming—West Texas Naphtha

Charge:	
IBP/FBP, °F.	228/332
Rvp, psi	1.0
RON, Clear	48.7
RON, 3.0 ml TEL	67.0
Percent Naphthenes	41
Percent Aromatics	12

RUN	1	2	3
Space Rate, V/hr./V	3.0	3.0	1.5
Inlet Temp., °F.	950	975	975
10-lb. Rvp gaso., vol. percent	100.0	96.2	90.2
Outside C_4, vol. percent	9.0	7.1	4.7
C_3 and Ltr., wt. percent	5.1	6.7	9.6
10-lb. Rvp. gaso., RON, 3.0 ml TEL	95.7	100.0	104.0 (CRC)
Calculated: ¢	9,020	10,440	12,220
RONB	2,740	3,130	3,430
¢/RONB	3.3	3.3	3.6

increases by varying reactor inlet temperature at constant space rate (V/hr./V) and by varying space rate at constant temperature. Calculated incremental costs for increasing temperature (Run 1 vs. Run 2) and for reducing space rate (Run 2 vs. Run 3) are 3.6 and 5.9 cents per RONB, respectively.

An economic survey of catalytic reforming in modern refineries has been presented by Burtis and Noll[87] by starting with a 10,000-bpcd (barrels per calendar day) refinery charging East Texas Crude. For a refinery with thermal cracking equipment, replacing thermal reforming with Houdriforming was shown to provide an incremental investment payout of 2.2 years (before federal taxes). Similarly, in a refinery with catalytic cracking, an attractive incremental investment payout was indicated for Houdriforming replacing thermal reforming. Also noted were economics in favor of mild Houdriformer operation versus severe operation. The article gives a complete economic basis (price structure, unit investments, and operating cost components) and thereby

affords a convenient basis for making general economic studies.

Noll, Burtis and Dart[233] have published information concerning the proper selection of charge stocks and reforming severity. Economic selection of charge stock boiling range and severity for the Houdriforming of a typical sweet naphtha was illustrated. Economics favored moderately severe Houdriforming (78 to 82 RON clear) of the narrowest boiling 400 F. end point naphtha with which it is possible to reach a desired octane level. Condensed data are given in Table 26. Increasing severity on

TABLE 26—Yield-Octane Data—Houdriforming

Charge Stocks (IBP-FBP) °F.	205-400		300-400	
Percent Naphthenes	45		46	
Percent Aromatics	13		14	
RON, +3.0 ml TEL	77		73	
Results:				
RON, clear, 10-lb. Reformate	75	85	75	85
RON, +3.0 ml TEL, 10-lb. Reformate	91.0	95.0	87.5	89.7
Yield, 10-lb. Reformate, vol. percent	101.5	97.0	107.3	104.5
Excess C_4 required, vol. percent	7.1	4.0	9.4	7.8
Dry gas, Mm Btu Bbl.	0.176	0.298	0.076	0.124
Calculated, ¢/RONB	7.0	6.4	5.7	5.5

the 205-400 F. charge is calculated at 4.6 cents per RONB while that on the 300-400 F. charge is 4.7 cents per RONB. Increasing the boiling range under moderately severe conditions (85 RON, clear, reformate) is calculated at 8.4 cents per RONB.

On a comparison using two cuts of East Texas naphtha, Fowle et al.[102] found that the cut minus the C_6 and lighter fraction gave a pronounced improvement in yield-octane relationship. At a 96 volume percent yield of 10-pound material, the heavier feed gave 7 octane numbers (Research) more improvement than the lighter feed.

Teter et al.[297] in discussing flexibility with the Sinclair-Baker catalyst, noted two alternates. When running for 80 to 90 RON, clear, reformate, continuous catalytic reforming may be employed. When running for over 90

TABLE 27—Yield-Octane Data—Sinclair Baker Process

FEED STOCK	Mid-Continent		Kuwait	
IBP/FBP, °F.	236/373		240/355	
Percent Naphthenes	43.2		19.4	
Percent Aromatics	7.7		14.7	
RON, clear	36.5		29.6	
RON, 3.0 ml. TEL	61.0		52.5	
OPERATION	**500 psig Continuous**	**200 psig Regenerative**	**500 psig Continuous**	**200 Regenerative**
Products:				
10-lb. Rvp, vol. percent	89.4	94.8	84.4	92.8
RON, 3 ml TEL	99.8	99.9	99.9	99.4
Dry gas, wt. percent	9.0	8.8	14.8	8.6
Excess C_4 required, vol. percent	4.0	7.9	0.3	6.7
Calculated ¢/RONB	3.4	2.9	3.0	2.6

RON, clear, a regenerative type operation may be required. As distinguished from continuous operation, the latter scheme embodies facilities to regenerate a portion of the catalyst without interrupting the processing cycle. Also given were the data in Table 27 with which cents per RONB calculations have been made.

Fowle et al.[102] have also reported pilot reforming data as shown in Table 28 (Atlantic Catforming process) with which cents per RONB values may be estimated.

Grane[114] reported in late 1953 the first commercial Catforming data obtained on the 750-bpd reformer at the Prewitt, N. M., refinery of Malco Refineries, Inc. An

TABLE 28—Yield-Octane Data—Pilot Catforming

TYPE CHARGE	East Texas		West Texas	Mid-Continent	California	Gulf Coast
RON, 3.0 ml. TEL	75 (est.)		70.0	63.1	76.1	66.9
Percent Naphthenes	47.6		38.7	36.1	59.6	36.4
Percent Aromatics	9.2		20.8	15.7	13.0	16.8
Vol. Percent Yield, C_5+	90.0	86.7	89.2	89.5	88.4	85.2
Vol. Percent Yield, C_4	3.9	7.5	7.7	5.5	4.1	11.8
Wt. percent C_3 & Ltr.	3.4	5.0	3.8	5.3	4.8	4.7
RON, 3 ml TEL, C_5+	93.0	97.1	92.9	94.1	99.6	96.3
Rvp, C_5+	1.8	2.3	1.8	2.2	4.0	2.5
Calculated ¢/RONB	5.0	5.0	3.9	2.9	4.8	3.5

8.5 pound-RVP, 56.2 RON (3 ml) naphtha charge was shown to yield a 10-pound RVP reformate of 91.2 RON (3 ml) equal to 104.3 percent by volume of debutanized feed.

Faulkner et al.[93] reported commercial data on Catforming obtained on the first commercial unit, a 750-bpd reformer that went on stream August 4, 1952, at the LaBlanca refinery of McBride Refining Company as shown in Table 29.

TABLE 29—Yield-Octane Data—Commercial Catforming

FEED STOCK	Donna Crude	LaBlanca Crude
Rvp	3.5	5.0
RON, clear	56.0	30.8
Percent Naphthenes	35.3	19.1
Percent Aromatics	13.0	4.4
Product:		
10-lb. Rvp reformate, vol. percent	99.9	95.9
Excess C_4, vol. percent	—3.2	—0.2
C_3 and Ltr., wt. percent	4.0	3.4
RON, 10-lb. 3 ml TEL	93.5	84.5
Calculate ¢/RONB	4.7	2.6

Thornton[300] has also reported on the initial operation of the McBride Refining Company Catforming unit. The economic aspects of reforming were illustrated by comparing net refinery revenue before and after reforming. On gasoline equal to 23 percent of crude (2.5 percent premium), made by blending outside natural gasoline 50-50 with straight-run and by adding 15 percent of purchased high-octane at 2.5 cents per gallon over market to the premium blend, reforming was shown to be profitable. Reforming was shown to permit increasing qualities from 88 and 84 RON to 91 and 86 RON on premium and regular, respectively, (thereby increasing 0.25 cents per gallon in value), to stop outside purchases of high-octane stock, and to increase net refinery revenue by the amount of 0.087 cents per gallon of gasoline (two grades).

Forrester et al.[97] announced the Ultraforming process in March, 1954, at the annual WPRA meeting. The process was reported to take advantage of high yields and octane numbers offered by operations at low pressures using a platinum-on-alumina catalyst regenerated by a novel technique. In commenting on catalyst life, the authors stated that catalyst life when Ultraforming at 300 psi should be in excess of 150 barrels charge per pound, while Ultraforming at 200 psi should permit catalyst life beyond 40 barrels per pound. Aging tests had not indicated a practical limit. Pilot data given in the paper are shown in Table 30.

In an excellent analysis of the factors to be considered in selecting a catalytic reforming process, Steel et al.[289]

TABLE 30—Yield-Octane Data—Ultraforming

	Gulf Coast		Mid-Continent		Arkansas
Pressure, psi	300		200		300
Charge:					
IBP-FBP, °F	202-394		206-361		149-377
RON, clear	59.4		44.5		45.3
Percent Naphthenes	55.5		41.5		15.0
Percent Aromatics	18.5		8.5		8.0
Product:					
C_5+ Reformate					
RON, clear	90	100	85	95	90
Vol. Percent	91.8	83.8	90.5	84.1	80
Rvp, psi	2.0	3.3	2.1	2.6	6.0
C_4, vol. percent	2.7	6.2	2.0	4.4	9.3
Dry gas, wt. percent	3.4	7.2	3.3	6.7	9.8
¢/RONB, Calculated	4.0	4.4	3.2	3.4	4.6

grouped processes into three types: (1) Non-regenerative platinum fixed-bed reforming at high pressure, (2) Regenerative non-platinum fluid or moving-bed reforming at lower pressure, (3) Regenerative platinum fixed-bed reforming at lower pressure. Using data on three naphthas, comparisons of yield-octane relationships, octane potentials, butane yields, and reformate volatility (RVP) were made. Catalyst replacement cost was stated to be the item which varies most among processes. Catalyst life of 15 to 25 barrels of feed per pound of catalyst were noted for operations producing 93 RON clear reformates for non-regenerative platinum processes and twice that for regenerative processes. Much longer life would be expected for milder operations. Replacement rate for non-platinum fluid operation would be about 0.2 pound per barrel of feed. Replacement costs of $4 per pound for platinum catalyst and 60 cents per pound for fluid molybdena were cited. Three illustrative cases covering different charge stocks, reformer sizes, and feed and product values are given in the paper. Using the cases presented by Steel et al.,[289] cents per RONB calculations have been made as shown in Table 31.

TABLE 31—Yield-Octane Data—Process Types

FEED	Mid-Continent			Gulf Coast		Mixed (14% Coker Naph.)		
RON, clear	44.5			59.4		46.1		
Percent Naphthenes	41.5			55.5		37.5		
Percent Aromatics	8.5			18.5		14.0		
	1	2	3	2	3	1	2	3
Dry gas, wt. percent	11.4	11.7	7.5	10.7	6.1	12.6	12.3	8.7
C_4, vol. percent	5.6	6.2	4.5	5.6	5.2	5.5	6.1	4.4
C_5+, vol. percent	80.2	79.0	84.7	80.5	86.0	79.6	78.4	84.1
RON, clear	93	93	93	98	98	93	93	93
Rvp, psi	2.0	2.4	1.6	3.3	2.2	1.1	1.6	0.7
Calculated ¢/RONB	4.1	4.3	3.5	5.5	4.3	3.6	3.8	3.0

1. Non-regenerative Platinum reforming; 2. Fluid Molybdena reforming; 3. Regenerative Platinum reforming.

Yield-Octane Economics—Other Catalysts—Extensive catalytic reforming pilot data over a chromia-alumina catalyst have been documented by Hughes et al.[176] One feed stock, West Texas naphtha, was reformed to three octane levels, and the data permit generalization with the improvement cost relationship. The pilot data also was found to correlate well with the characterization factor, K. Data on the West Texas naphtha (60 RON clear, 33 percent naphthenes, 19 percent aromatics) were given as shown in Table 32. Comparing the two high temperature operations with the next lowest temperature data, one may calculate that the first temperature increase gives incremental improvement at 11.2 cents per RONB and the second increase gives improvement at 17.9 cents per RONB.

Also given in the Hughes discussion were data ob-

TABLE 32—Yield-Octane Data—Chromia-Alumina Catalyst

Reforming Conditions:			
Temperature, F	958	977	1008
Pressure, psig	100	100	100
V/Hr./V	1.0	1.0	1.0
Yields, vol. percent charge:			
10-lb. reformate	99.6	93.8	85.5
Excess butane required	8.6	5.9	4.3
Dry gas, wt. percent	6.6	8.8	13.5
RON, 3 ml TEL:			
10-lb. reformate	97.0	99.2	102.1 (CRC)
Calculated ¢	9,180	10,980	14,030
RONB	1,820	1,980	2,150
¢/RONB	5.0	5.6	6.5

tained under identical conditions on the separate hydrocarbon fractions of a 300 to 400 F. Illinois naphtha as shown in Table 33.

Data obtained on a 50-bpd pilot Thermofor Catalytic Reforming unit were used as the basis for illustrating commercial applicatoin of the process in a 30,000-bpd

TABLE 33—Yield-Octane Data—Reforming Various Feeds Over Chromia-Alumina Catalyst

	Total 300-400 F.	Non-Aromatic	Iso-Paraffins + Naphthenes	n-Paraffins
New Aromatics, vol. percent charge	37	39	37	38
RON, clear, charge	32.4	16.8	38.4	54.4
RON, C^{4+} reformate	91.8	90.0	89.2	86.8
Yield, C^{4+} reformate, vol. percent	82.4	78.4	81.6	74.1

refinery by Payne et al.[243] To make a pool octane number of 93 RON (3.0 ml TEL), a 3600-bpd TCR unit charging 260-410 F. naphtha was required in one case and a 5700-bpd thermal reformer charging 200-380 F. naphtha in another case. The latter also required a 1300-bpd catalytic polymerization plant. The relative quantity and quality of components comprising motor fuel before reforming were given as follows (1952):

	%	RON + 3 ml TEL
Catalytic gasoline	31	98
Thermal gasoline	26	89
Straightrun plus natural gasoline	33	84
Heavy straightrun	8	68
Polymer	2	115
	100	89 pool RON

TCR investment was $3.1 million (1952) versus thermal reforming of $2.06 million. Incremental TCR savings were shown to pay out the added investment in 1.4 years. Some of the 50-bpd pilot TCR data have been used to calculate order-of-size octane improvement costs as shown in Table 34.

Reforming Cracked or Synthetic Naphthas

Fractions of certain cracked naphthas are low enough in octane number to afford a means of octane improve-

TABLE 34—Yield-Octane Data—TCR Pilot Plant

	Colombia (Paraffinic)	Mixed Texas	Depentanized West Texas	Calif. (Wil.)	54% St. Run 45% Coker
Charge:					
Percent Aromatics	11.3	8.8	15.9	16.0	14.7
RON, 3.0 ml TEL	60.6	69.4	75.2	71.5	75.4
Products:					
10-lb. Rvp Reformate, vol. percent	82.0	87.2	96.1	85.4	94.0
RON, 3.0 ml TEL	99.1	97.1	96.5	101.4	97.9
Excess Butane required, vol. percent	—1.0	0.6	6.4	2.7	6.1
Dry gas, wt. percent	16.1	12.1	8.6	14.5	10.0
¢/RONB	4.2	5.0	5.4	5.3	5.5

ment by the double effect of withdrawing a low quality material from gasoline blends and returning a higher quality material. Le Roi and Ferguson in 1933[193] gave data on thermal reforming of thermally cracked naphtha. Some of the data are tabulated in Table 35. Degradation

TABLE 35—Thermal Reforming of Cracked Naphtha

Charge	260-415 F. Cracked Naphtha Octane No. = 52		31 ON Straightrun	
Operation	Octane Improvement	Degradation Percent/ON	Octane Improvement	Degradation
Recycle.....	52 to 80.2	1.21	31 to 59.2	0.38
Recycle.....	52 to 81.8	1.42	31 to 60.6	0.39
Once through	52 to 70	0.59	31 to 49.0	0.29
Once through	52 to 80	0.76	31 to 59	0.30

rate is noted to be somewhat higher for the cracked naphtha.

According to Draeger et al.,[79] large quantities of lightly branched olefins and paraffins are present in thermally reformed naphthas and quantities of aromatics and naphthenes are small. Further noted was the fact that naphthas from residuum and gas oil thermal cracking are relatively low in octane number. Recracking in coil-only or coil-and-drum thermal units of heavier fractions (189-400 F., 62 RON) was said to yield about 85 percent of a C_4-400 F. naphtha of 78 RON, clear, or 75 percent of a naphtha of 82 RON, clear.

Thermal processing of catalytically cracked naphtha has been discussed by Pollock.[249] In a pilot plant comparison, thermal cracking of a nominal 400-500 F. fraction of catalytically cracked product was shown to give better over-all results than thermal cracking of a straight-run material of the same boiling range. For the catalytic charge a 60 volume percent yield of 98 RON clear product (90 percent @ 405 F.) was shown vs. a 55 percent yield of 71 RON clear product for the straight-run material. Thermal conversion was shown to consist of a slight increase in heavy aromatics (above C_{12}), extensive olefin production in all fractions, over-all loss in naphthenes (to cracking), and extensive formation of new paraffins in the C_1 to C_5 range. Paraffins decreased considerably over-all.

Where hydrocarbon composition of the naphtha lends itself to octane improvement by aromatics formation and paraffin isomerization rather than olefin formation through cracking, the catalytic reforming processes offer better means of improvement than thermal processes. A catalytic reformate containing essentially paraffins and aromatics only can be processed to segregate a 95 percent aromatic and a raffinate of 30-40 octane number which can be thermally reformed, according to Draeger.[79] The product yield and octane improvement are comparable to those obtained in conventional reforming of virgin naphtha. Thermal aftertreatment of catalytically cracked naphthas was practiced during World War II by some refiners in order to produce a highly aromatic naphtha as a Supercharge Rich rating corrector in aviation blends. Catalytic aftertreating was even more common, providing large volumes of critically needed aviation base stock by second-passing through catalytic cracking units.

McGrath[214] has reported pilot fluid hydroforming data on a high sulfur California cracked naphtha (142-384 F.):

10 lb. RVP product, vol. %	97.0
Outside C_4 for 10 lb., vol. %	6.2
RON, clear, 10 lb. product	84.4
RON, 3.0 ml TEL	95.7
Dry gas, wt. %	5.8
Sulfur removed, wt. %	0.90

Haensel[123] has given data illustrating the Platforming of a West Texas cracked naphtha alone and in a blend of equal parts of the cracked and West Texas straight-run naphtha. Leaded Research octane numbers up to 98.0 at 3.0 ml TEL were shown to be obtainable on the product. No yield data were given.

Read[257] reported pilot Platforming data on a C_6 to 340 F. fraction of fluid catalytically cracked naphtha. Yields were 7 weight percent C_4 and lighter gas and 92 volume percent debutanized Platformate. The charge stock, 55.9 °API, 1.5-pound RVP, Bromine No. 73, had RON, clear, of 92.2 and RON, 3.0 ml TEL per gallon of 98.2. Corresponding properties of the debutanized Platformate were 86.2 and 96.3, respectively. Catalyst effects were not discussed. By the octane decrease and TEL susceptibility increase one surmises that the principal conversion was saturation of olefins and perhaps conversion of very light naphthenes.

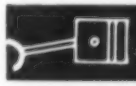
Weinert et al.[320] presented data on the Platforming of a blend of 70 percent Santa Maria valley coker distillate and 30 percent Los Angeles straight-run. Yields of 99.2 volume percent, 10-pound RVP Platformate (6.3 percent extraneous butane), 4.0 volume percent butanes, and 7.4 weight percent dry gas were reported. Quality of the 10-pound RVP Platformate was 86.4 RON clear, 95 RON, plus 2.0 ml TEL per gallon. Donaldson et al.[78] reported extensive data on Platforming a hydrogenated Fischer-Tropsch naphtha consisting of n-paraffins C_8H_{18} through $C_{11}H_{24}$) to emphasize conversion of paraffins to aromatics by dehydrocyclization. Inasmuch as the feed stock consisted mainly of n-paraffins, some of the data are considered of interest and are reproduced in Table 36.

TABLE 36—Yield-Octane Data—Platforming Hydrogenated Fischer-Tropsch Naphtha

Charge Stock	RON, Clear °API IBP-FBP, °F.	—50 64 268-369
Results:		
Temperature, C	500	450
Hydrogen, CF/Bbl.	816	572
C_1 to C_4, CF/Bbl.	447	278
C_4, vol. percent	16.3	10.7
C_{5+}, vol. percent	64.9	78.1
RON, clear	97.4	74.4
Percent Aromatics	63.2	38.3

Heinemann et al.[152] have reported data on Houdriforming of hydrocracked naphthas. Hydrogenative processing of heavy oils was stated to give large yields of relatively low octane number gasoline. An example of naphtha from hydrocracking the 56 to 77 percent fraction of an East Texas crude was given as follows:

IBP-FBP °F.	75-457
Fraction to 190 F.	18%
RON, clear	86
Fraction 190 to 408 F.	
% Naphthenes	40
% Aromatics	23
% Paraffins	36
RON, clear	63



How To Get Those Top Octanes

Hydrocracked naphthas were stated to perform much like virgin naphthas upon being catalytically reformed. A 231-374 F. fraction of hydrocracked naphtha having RON (clear) of 45.1 and RON (3.0 ml TEL) of 64.2 was Houdriformed to a C_5+ yield of 85 percent. Product quality was 86.0 RON (clear), 94.8 RON (3.0 ml TEL). Percentage aromatic in charge was 14 percent and that in the C_5+ product was 52 percent.

In describing several processes that may be used to increase octane rating of a refinery's total gasoline blend, Read[254] in 1946 discussed the Isoforming process. The process was designed to increase the octane rating of cracked gasoline by isomerization of the olefins. The process was fixed-bed, regenerative, catalytic, 750-1000 F., and low pressure (5-20 psig). Pilot data on Isoforming a 68 octane number thermally cracked gasoline were given as follows:

Charge:		
	400 F. EP	
	MON, clear	68.1
	MON, 3.0	76.6
	RVP, psi	9.9
Isoformed		
Yield, vol. %		98.5
MON, clear		73.4
MON, 3.0 ml TEL		81.0
RVP, psi		10.0

Isoforming thermally cracked naphtha in lieu of thermal reforming straight-run increased Motor octane number (+3.0 ml TEL) from 77.3 to 78.7 and increased yield in a hypothetical refinery showing octane improvement progression for various process alternates. Thermal reforming and Isoforming conducted simultaneously increased MON (+3.0 ml TEL) of the gasoline pool to 81.2. Armistead in 1946[27] discussed Isoforming as an application of isomerization of motor gasoline constituents. The process has little or no effect on catalytically cracked naphthas, indicating a selectivity for certain lower-octane hydrocarbons present in thermal naphthas. On a delayed coker naphtha a Research, clear, improvement of 12.2 octane numbers was accompanied by a RVP increase of 3.1 psi.

Berg et al.[42] reported that olefins in thermally cracked distillates could be isomerized at 375-425 C. over alumina impregnated with anhydrous HCl. Octane improvement averaged 4 units, and liquid yields in excess of 95 percent were obtained. Octane number increase data at 400 C. were given as shown in Table 37.

Because of their application as a means of pretreating catalytic reformer charge stocks, hydrogen pretreating processes merit comment in a review of octane improvement economics. For straight-run naphthas of abnormally high sulfur, nitrogen, and metals, and for thermally cracked naphthas and coker gasolines, hydrotreating provides a means of processing these marginal quality stocks into ideal catalytic reformer feeds. Such pretreatment is understood to be particularly required of cracked naphthas when platinum reforming is practiced. Among naphtha stocks, coker naphtha is the lowest quality component that must be blended into gasoline. It therefore is potentially an attractive route for improvement because the octane-barrel effect is large.

TABLE 37—Yield-Octane Data—Olefin Isomerization

OLEFIN	Orig. ON	Isomerized ON	Increase
1-Octane	36.8	75	38.2
Codimer	83	83.4	0.4
DeC_4 polyformate	72-73	74-75	2.0
DeC_4 coker naphtha	70.3	72	1.7
DeC_4 thermal naphtha	66-68	69-72	3-5

Unifining is one such hydrotreating process on which data have been published.[120] Erected plant costs were estimated to be $75 to $175 per barrel of charge for a 5000 B/SD Unifiner. The following economic factors were given for a 5000-bpsd unit to treat a mixture of high-sulfur cracked and straight-run naphthas:

Estimated Plant Cost	$750,000
Operating Costs, cents per barrel	
Labor	2.6
Utilities	2.8
Catalyst	2.0
Hydrogen Consumption	1.5
Maintenance (4 percent Inv.)	1.8
Insurance, Taxes (2½ percent)	1.2
Total, ex royalty, depreciation, overhead	11.9

Isomerization of Paraffins

Frost[104] gives a tabulation of octane numbers (Motor) of equilibrium mixtures of isomeric hydrocarbons (over $AlCl_3$) and similar data are shown in Figure 3 as published by Hettinger, Keith, Gring and Teter.[164] Thus, as pointed out earlier under Hydrocarbon Chemistry, a limitation on octane improvement by isomerization of light paraffins appears to be an octane ceiling imposed by equilibrium. Evering et al.[92] summarized the effects of isomerization of pentanes and hexanes as shown in Table H.

TABLE H

	B.P., °F.	RVP, psi	MON, Clear
iC_5	82	21.0	90
nC_5	97	15.5	62
2,2-Dimethylbutane	122	9.4	94
2,3-Dimethylbutane	136	7.1	94
2-Methyl pentane	141	6.5	74
3-Methyl pentane	146	5.8	74
nC_6	156	5.0	26

Assuming 100 percent conversion and 100 percent selectivity with regard to normal pentane isomerization, the cents per RONB equation gives an octane improvement cost of 2.8 cents per RONB on an unleaded basis. At 3.0 ml per gallon, cost would be considerably higher because the difference between the normal pentane RON + 3.0 ml TEL and the pool quality would be much less. Economics are sensitive to butane prices because of the RVP increase when producing isopentane.

Once-through yields on pentane isomerization were given as follows by Evering:[91]

	Wt. %
Dry Gas	0.1
C_4	1.7
iC_5	62.0
nC_5	34.8
C_6+	1.4

Galstaun[106] mentioned that the 50-60 volume percent isopentane yield on a once-through operation could be increased to 97 percent by recycling and that side reactions were slight.

Parker[241] reported economics of pentane isomerization: Isopentane cost for a 2000-bpd plant varied from 3 to 7 cents per gallon with respective normal pentane values

of 2 to 6 cents per gallon. A 1945 price structure was used. A large pentane isomerization unit was indicated to increase the value of isopentane about 1.15 cents per gallon over the feed stock value. A slim margin was indicated in favor of C_5 isomerization in large refineries. The economics were based to some degree on untried operations, however. Further, the vapor pressure penalty was not considered in the above costs. No feed preparation costs were included, and at the time of Parker's study, such processes required relatively pure feed stocks.

Evering[91] has given yields in hexane isomerization as shown in Table 38.

TABLE 38—Yield-Octane Data—Hexane Isomerization

	C_6 Feed*	Once Thru	1:1 Recycle	2:1 Recycle
Dry gas, vol. percent	....	1.8	3.6	5.3
C_4, vol. percent	....	3.8	6.3	8.7
Products, vol. percent	....	96.8	87.2	85.2
Bottoms, vol. percent	....	....	7.0	6.2
Product MON, clear	65	80	88	91.4

* Mid-Continent.

Swearingen et al.[295] reported that two Isomate plants (5000 bpd and 1750 bpd) had been constructed and successfully operated (1946). Operating cost was reported as 0.7 to 1.0 cents per gallon of reactor charge. For low octane normal paraffins, the process was competitive with TEL, while for mixed C_5-C_6 feeds, it was not competitive at 1946 octane levels. Typical Isomate feed and product data were as shown in Table I.

TABLE I

	35% C_5, 65% C_6		Mixed Hexanes	
FEED	Feed	Isomate	Feed	Isomate
RVP	10.0	10.0	4.9	7.1
MON, Clear	70.1	79.8	69.5	79.4
+ 1.0 ml TEL	80.0	89.7	80.3	89.4
+ 3.0 ml TEL	87.2	95.9	86.5	93.6

Poly and Alkylate Play a Part . . .

The emphasis herein has been on octane improvement economics. Because processes such as polymerization, alkylation, and catalytic cracking are not truly improvement processes but rather means of converting non-gasoline hydrocarbons into favorable market price products, these have not been considered in the scope of this discussion. Of course, any process providing a high octane gasoline component is an integral part of a refiner's octane position as discussed by Weber.[317] Economics of such processes, however, seldom hinge on octane improvement.

Polymerization and alkylation processes perhaps merit some coverage in this discussion because of several factors. To the extent Motor octane number again assumes importance as a gasoline antiknock quality specification, alkylation will represent a means of Motor octane number improvement. Further, stability problems that could be sustained from high catalytic polymer concentrations in future high octane fuels might occasion consideration of alkylation in order to provide a saturated, stable blending agent in place of the unsaturated polymer. An excellent treatise on the alkylation process as practiced in modern refining is given by Mrstik et al.[223] Maschwitz and Henderson[208] have also prepared a thorough study of commercial polymerization, covering thermal polymerization, gas reversion, phosphoric acid and sulfuric acid polymerization.

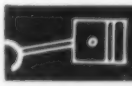
The first commercial alkylation units in the U. S. were built about 1938 and employed sulfuric acid as a catalyst. In 1942 the first commercial plant using hydrofluoric acid as a catalyst was put into production. By 1945, as described by Mendius,[219] 60 alkylation units were in operation producing 130,000 barrels per day of aviation alkylate. Some 60 percent of these plants, accounting for two thirds of this production, were of the sulfuric acid type. The remaining 40 percent of the plants used hydrofluoric acid catalyst and accounted for one-third of the 130,000 barrels per day. Total alkylation capacity rose to 178,000 barrels per day at the end of the war, according to Weber.[316]

As pointed out by Mrstik, Smith & Pinkerton[223] the trend toward jet engines for aircraft indicates a decreasing demand for alkylate in the long range future. The drawback to the alternative use of alkylate in motor fuels is the high cost of alkylate manufacture. Catalyst cost alone, in the case of propylene alkylation, is estimated at 2.5 to 3.0 cents per gallon of alkylate produced. The necessity of operating with a considerable excess of isoparaffin in the reaction zone also makes the process expensive. Improved reactors and/or catalysts may help to make alkylate economically attractive as an ingredient of high-octane motor gasoline blends.

Alkylation is generally not as economical as polymerization for motor fuel production, unless operated on a large scale where isobutane is readily available, as discussed by Haensel.[123] Alkylation has been widely used for the production of aviation gasoline, and got its impetus during World War II.

Parker[241] reported general studies of the economics of alkylation for motor gasoline. For a 5000-bpd plant, the cost of C_3-C_4 alkylate varied from 6 to 11 cents per gallon depending on whether olefins and isobutane were costed at 2 or 6 cents per gallon. At the time house-brand motor fuel sold for 6 cents per gallon f.o.b. refinery, Parker concluded that even a small plant (500 bpd) might profitably make alkylate for motor fuel if charge stock is valued at 2.0 cents per gallon and if the octane credit for alkylate is measured in TEL (3 to 4 cc per gal., in 79 RON housebrand and 86 RON premium). Time has borne out Parker's conclusion that the economics were marginal inasmuch as most war time plants were shut down and few have been constructed for motor fuel operations. Butane isomerization was also judged to be marginal economically.

Sutherland and Doegey[294] concluded from economic studies that motor fuel from alkylation and polymerization of C_3 and C_4 olefins is profitable. For alkylation, however, normal and iso-butane must be available at a considerable margin below gasoline level. If casinghead prices are right, alkylation may be more profitable



than polymerization in larger plants (500 bpd olefins). Yields, operating costs, and comparative economics were given.

Investment and operating costs for sulfuric acid alkylation reactors have also been published by Jewell and King.[180] Data are given for both internal emulsion circulation and external emulsion reactors of various capacities.

Polymerization, while it produces a high-octane product, is not strictly an octane-improvement process in the sense that reforming and isomerization are. Rather, it converts light hydrocarbons into usable motor fuels, adding to the refiner's total inventory of octane-number barrels.[178] Polymerization is a necessary adjunct to thermal reforming, as described earlier in this paper, in order to properly utilize the light olefins which are produced by by-products of thermal reforming. The combination of thermal reforming with thermal polymerization in a single unit gave rise to the Polyforming process.

Catalytic polymerization can be carried out in the presence of either phosphoric or sulfuric acids using a variety of specific techniques, as reviewed by Maschwitz and Henderson.[208] These specific techniques may be outlined as follows:

1. The phosphoric acid on quartz catalyst process developed by Standard Oil Company of California and described by Langlois and Walkey.[192]

2. The phosphoric acid on kieselguhr catalyst process developed by Universal Oil Products Company and described by Weinert and Egloff.[219] These units may take one of three forms:

   A. A low-pressure, regenerative type operation. Pressures of 250 psi are typical, as are olefin conversions of 80 percent, and a catalyst life of 50 gallons per pound catalyst.

   B. A high-pressure operation using chamber-type reactors, operated at 500 psi. Olefin conversion of 85-90 percent and a catalyst life of 75 or more gallons per pound of catalyst are typical.

   C. A higher pressure operation using a multitubular reactor and a circulating heat-removal medium outside of the tubes. Operating pressure is 900 psi, olefin conversion is 92 percent and catalyst life is 150 gallons per pound catalyst.

3. The liquid sulfuric acid processes developed by Shell Development Company and described by McAllister.[211]

   A. A cold acid (70-100 F.) process which selectively polymerizes isobutene.

   B. A hot acid (170-210 F.) process which polymerizes all C_4 olefins.

Non-selective polymerization of C_3 and C_4 olefins was analyzed economically by Parker.[241] With charge at 4 cents per gallon, a large plant was shown to produce polymer butane free at a cost of 7.6 cents per gallon. With lower value butanes (2.0 cents per gallon) polymerization was indicated to be attractive for even the smallest refinery.

Don't Forget Process Combinations . . .

In the octane study by Draeger et al.,[79] attention was called to the fact that a fairly good segregation of high and low octane components can be effected by precise distillation of virgin naphthas boiling up to about 210 F. The usual procedure on a C_6-210 F. virgin naphtha consists of taking overhead on three successive towers the following cuts: a C_6-145 F. isohexane fraction, containing cyclopentane; a 145-165 F. normal hexane fraction, containing some methylcyclopentane; and a 165-195 F. isoheptane fraction, containing dimethyl pentanes and dimethylcyclopentanes. Yields and Motor octane numbers are as follows:

Fraction	MON	Vol. %
Isohexane	81	20
Normal hexane	52	27
Isoheptane	72	40
Normal Heptane	40	13
		100

By superfractionation, refiners may isolate the extremely low octane components and either process them in the most economic manner for octane improvement or they may develop alternate markets for such components, relieving the gasoline pool octane number situation.

Several factors point to the ultimate need on the part of refiners to engage in combinations of processes centering around reforming for octane number improvement. Premium grade octane numbers are reaching octane levels beyond that of any major constituent of the gasoline pool. A need for high octane blending agents is therefore developing. Aromatic concentrates may provide such agents. Equilibrium does not favor octane improvement by catalytic reforming of naphthas already high in aromatics. Therefore, extraction prior to recycle or separate reforming may be expedient. Separation facilities are required to effect optimum improvement of the lighter paraffins by isomerization and dehydro-cyclization. Processing naphthas to very high octane levels may require separate reforming of certain portions over catalysts designed to be selective to a more specific reaction than the number of reactions involved in conventional reforming.

Read[258] has illustrated the application of the Platforming and Udex processes for production of high purity aromatics. Economics were worked out by projecting pilot plant data to an operation in which 10,000 bpd of naphtha was processed. Certain of the economic factors may be of interest to refiners considering the problem of very high octane stock production. Operating costs and utility requirements are given for prefractionation of naphtha, Platforming, and Udex extraction. Investments are also given.

In a study of aromatics production from natural gasoline by Platforming, Williams and Sutherland[323] gave economics of benzene manufacture. For a 1000-bpd Platformer and 300 bpd of benezene, the following direct operating cost components were given:

	$ per day
Supervision (25% of Labor)	24
Operating Labor, 2 men @ $2/hr.	96
Catalyst	125
Maintenance	90
Royalty	196
Taxes, Ins. @ 2.5%	73
Interest @ 4%	70

Solvent	18
Utilities	
Fuel, 20.5 x 10^6 Btu/hr	54
Water, 770 gpm	11
Steam, 2,400 lb. hr	14
Power, 130 kw	31
Total	802

Reference to such studies is considered pertinent inasmuch as octane improvement and not petrochemicals may be the impetus to increased processing of this type.

The implementation of the Platforming and Udex processes into a process permitting production of fuels of any useful octane rating was announced by Grote et al[110] as the Rexforming process. Economics were illustrated by the following figures for a 5000 bpsd unit to charge Mid-Continent full-boiling, straight-run naphtha and to produce a 101 RON, clear product. Actual reactor charge is 4300 bpsd.

Erected Cost (Battery Limits)	$1,600,000
Operating Costs, cents per barrel full boiling charge	
Labor	4.0
Laboratory	1.0
Utilities	17.3
Catalyst	6.9
Solvent	1.7
Maintenance (3 percent)	2.8
Ins. & Taxes (2.0 percent)	1.9
Total (ex. Royalty, Deprec., Adm., and Overhead)	35.6

The laboratory data in Table 39 were given for Rex-

TABLE 39—Yield-Octane Data—Laboratory Rexforming

Charge	RON, Clear Percent Aromatics IBP-FBP, °F.	30 8.0 248-390
Yields:	**Run 1**	**Run 2**
C_5, Rexformate	82.9	76.8
RON, clear	95.2	101.8 (CRC)
Separator gas, Scf/Bbl.	856	1,090
Debutanizer gas, Scf/Bbl.	246	296
10 lb. Rvp Rexformate	92.8	85.0

forming a Mid-Continent feed stock. By estimating leaded octane numbers and product vapor pressure, use of the equation for cents per RONB, on a generalized basis previously described, gives improvement costs of 3.0 and 3.7 cents per RONB for the two runs described above. Improvement by going from a Run 1 to Run 2 condition would cost 8.8 cents per RONB. Of course, use of the general equation may not be at all realistic because of the assumption regarding operating cost.

In systems employing Houdriforming plus additional processing, a new process name "Iso-Plus" has been adopted by Houdry Process Corporation. This article[234] is considered an excellent representation of current refinery octane problems. Economic comparisons are presented by postulating the reforming of 6000 bpcd of a typical 200-394 F. virgin naphtha containing 46 percent paraffins to a Research octane number of 100 clear. The naphtha has RON (clear) of 54.1, 37 percent naphthenes, and sulfur of 0.125 weight percent.

Four cases were considered: (1) Severe, one-pass catalytic reforming with frequent catalyst regeneration (2) Moderate Houdriforming of virgin naphtha, aromatics separation, and separate, mild Houdriforming of the paraffinic concentrate from extraction (3) Moderate Houdriforming in a single unit of virgin naphtha plus paraffinic raffinate from extraction, and (4) Moderate Houdriforming of virgin naphtha plus thermal reforming (and polymerization) of the Houdriformate. Cases 2 and 3 were stated to have potentials of 105 and 108 RON, clear, respectively, on net gasoline production.

Investments and operating costs for the 4 cases presented by Noll, Schall, Craig and Stevenson[234] are summarized in Table J.

TABLE J

CASE	6,000 Barrels per Calendar Day 6,600 bpsd	
	Investment, Dollars	Operating Expense, Dollars per Day
1	3,267,000	3745
2	3,598,200	3744
3	3,535,700	3960
4	2,915,800	2895

Further summarized are the following basic product effects for the four cases:

TABLE K

CASE	BARRELS PER CALENDAR DAY		
	10-Lb. Gasoline	X'S C_4 Regular	F.O.E.
1	5,004	138	853
2	5,447	— 66	650
3	5,228	41	744
4	5,155	—111	884
Base	5,930	—247	384

The "Base" case has been added to the information given in order to illustrate octane improvement costs as will be discussed below. To relate these situations to a hypothetical refinery, it will be assumed for this discussion that each of these operations is superimposed on an existing operational pattern in which moderate catalytic reforming has been employed in making a total gasoline pool that is 95 RON at 3.0 ml per TEL gallon. Such a pool would permit production of premium and regular grades of approximately 98 and 91 RON, leaded, respectively. It is estimated that catalytic reforming investment and operating costs for the base case would be about $2 million and $3470 per day (including 25 percent investment per year as total depreciation, interest, taxes, etc.), respectively. By adding this investment charge to the operating costs shown for Cases 1 through 4, we have in Table L a summary of the four cases and the constructed base case:

TABLE L

CASE	Total Reforming Cost, Dollars per Day	Cents per Barrel	Investment, Thousands of Dollars
Base	3470	57.8	2,000.0
1	4985	83.1	3,267.0
2	6204	103.3	3,598.2
3	6380	106.4	3,535.7
4	4895	81.5	2,915.8

Furthermore, assuming each 100 RON clear product has a RON blending value of 105 at 3.0 ml TEL, the cost of Research octane number improvement on total refinery gasoline can be determined for each case. Table 40 summarizes the calculations using the cents per RONB equation as a basis. The terms G and H are incremental yields of butane and fuel gas expressed as a function of the "charge," which for purposes of the calculation has

TABLE 40—Estimated Economics for Various Reforming-Processing Combinations

Case	1	2	3	4
¢/RONB Equation Terms				
V	84.3	91.8	88.0	86.7
F	0	0	0	0
RONo	97	97	97	97
G	6.5	3.1	4.9	2.3
H	0.47	0.27	0.36	0.45
E	25.6	46.0	49.0	24.0
Cents (numerator)	7,490	7,180	8,670	7,120
RONr	105	105	105	105
RONp	95	95	95	95
T	3.0	3.0	3.0	3.0
Research Octane Number Barrels	640	720	680	670
¢/RONB	11.7	10.0	12.8	10.6

been taken as the 10-pound RVP reformate made in the base case. The term E is incremental operating costs with respect to base case, expressed as cents per barrel of base case reformate, the "charge" to the four processing combinations. The octane improvement by the four cases has been calculated to be equivalent to increasing premium and regular grade octane numbers (3.0 ml TEL) from 98 and 91 to 100 and 93, respectively, on 320 barrels of gasoline per barrel of reformate so processed, when premium is about 30 percent of the gasoline production. The foregoing treatment of the "Iso-Plus" study illustrates the many factors to be considered and compared in projecting octane improvement programs.

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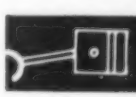
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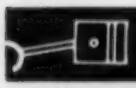
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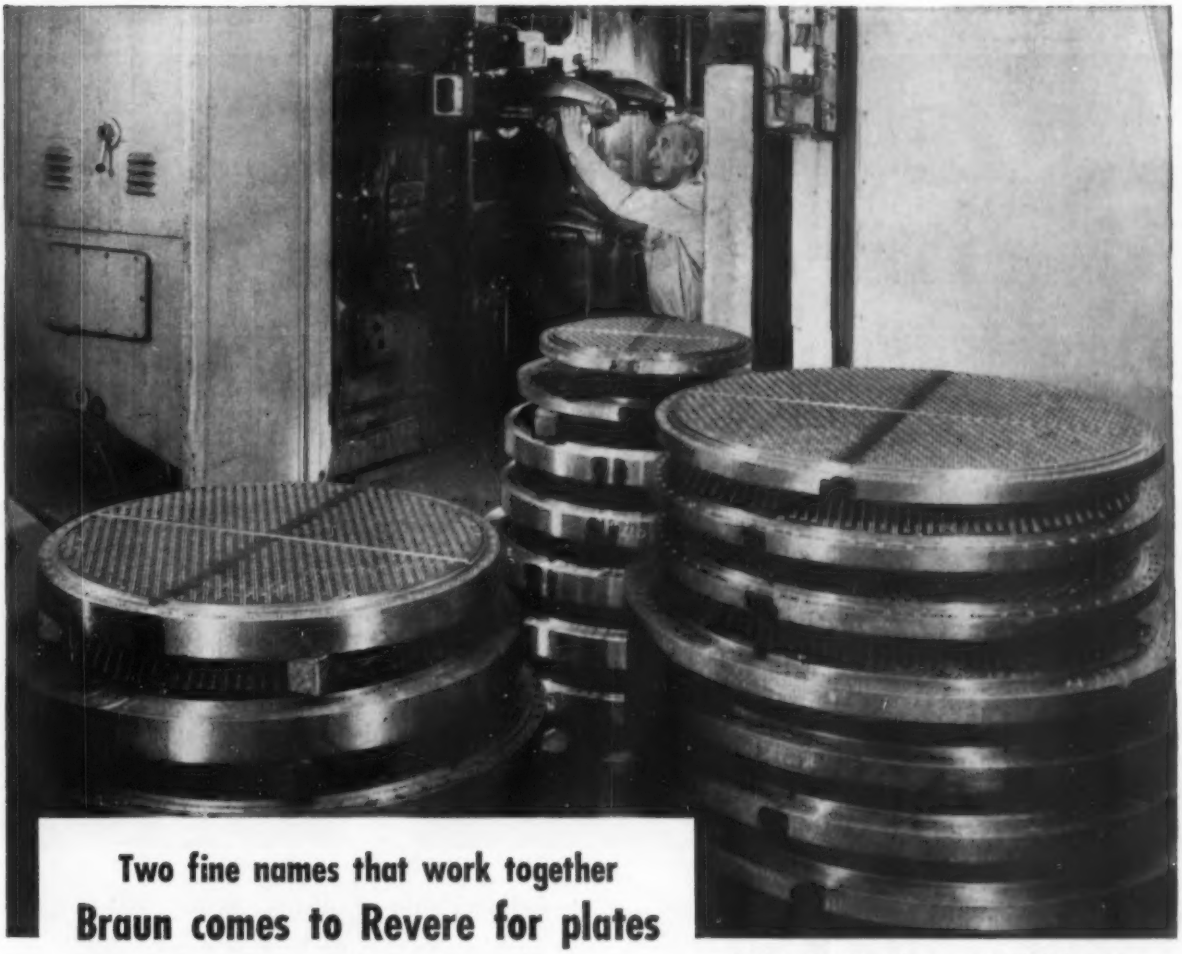

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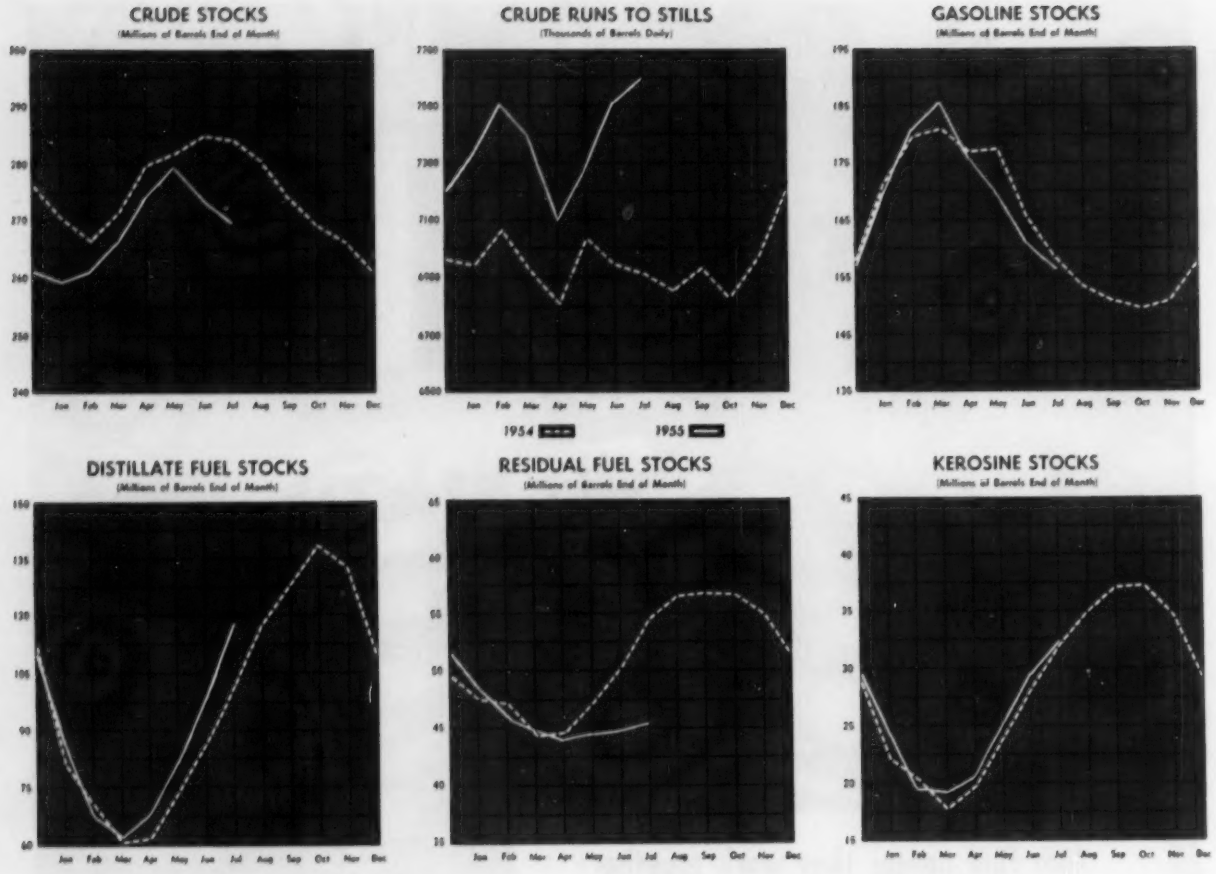

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Cecil W. Smith,
Economics Editor

- Refining rate at all-time peak
- Gasoline output at highest mark
- Distillate stocks gain heavily

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1953:													
July	6,603	7,103	284,976	3,583	143,916	321	31,143	1,441	102,258	1,224	47,530	629	950
August	6,583	7,163	285,352	3,592	146,050	321	35,711	1,437	119,542	1,222	50,007	672	946
September	6,557	7,023	289,614	3,521	144,184	330	37,280	1,448	126,709	1,203	50,516	692	1,013
October	6,262	6,872	287,541	3,437	144,495	355	38,161	1,462	135,409	1,184	50,820	639	990
November	6,277	6,987	283,021	3,528	150,747	354	36,271	1,463	133,381	1,223	51,267	648	1,120
December	6,238	6,964	276,676	3,628	159,949	378	29,070	1,441	111,944	1,247	49,370	598	1,121
1954:													
January	6,240	6,947	270,811	3,431	171,704	390	22,013	1,467	81,044	1,271	47,474	617	1,143
February	6,379	7,068	266,918	3,476	179,950	412	20,183	1,545	70,390	1,241	47,119	621	1,144
March	6,507	6,923	271,867	3,375	181,297	353	17,533	1,458	60,270	1,168	44,249	654	1,088
April	6,615	6,811	280,310	3,404	177,006	322	19,656	1,374	61,721	1,140	44,362	574	950
May	6,471	7,038	282,250	3,482	177,606	302	23,892	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	306	28,184	1,399	86,325	1,123	50,216	624	999
July	6,242	6,916	284,894	3,480	158,010	295	31,953	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	302	34,949	1,453	117,579	1,069	56,332	664	966
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	310	37,140	1,545	139,128	1,066	56,541	642	1,065
November	6,346	6,975	264,566	3,530	150,604	354	34,547	1,622	133,886	1,120	54,891	636	1,104
December	6,394	7,238	258,385	3,606	155,400	381	27,826	1,668	108,144	1,187	52,105	729	1,301
1955:													
January	6,761	7,379	260,156	3,639	160,562	409	23,266	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	374	18,291	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	357	18,187	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,538	697	1,123
May	6,677	7,268	276,948	3,595	168,751	296	26,375	1,519	83,559	1,111	45,083	742	1,137
June	6,616	7,508	273,338	3,670	160,305	279	29,790	1,640	99,461	1,124	44,911	742	1,063
July	6,623	7,599	269,642	3,732	156,627	286	32,339	1,560	118,367	1,114	45,325	789	1,085
Week Ended:													
8-13-55	6,701	7,505	262,469	3,816	155,563	311	33,431	1,565	124,979	1,116	46,349	732	1,041
8-20-54	6,156	6,936	277,788	3,404	155,017	310	33,830	1,466	111,444	1,131	55,848	665	932

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

"Completed by more than 7,000 Indian workers in the record time of eighteen months, despite two of the worst monsoons in Bombay's history, India's first major multiproduct refinery has imparted added firmness to the total economic picture of the country."
Bombay's Two Worst Monsoons

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Located on Bombay harbor, the new refinery was completed in 18 months — *six months ahead of schedule* — despite extraordinary difficulties.

One hundred sixty inches of rain fell in the area during the 1953 monsoon, and 180 inches in 1954, creating special drainage and grading problems and seriously interfering with work schedules. Insufficient roads made necessary the moving of heavy vessels by barge. Hundreds of the 7,000 Indian workmen employed on the job had to be trained in skills and construction techniques new to that country.

This is just one more example of how Lummus meets the challenge of difficult conditions. Our staff and facilities can complement *yours* on your next project.

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These Crane No. 47X 150-pound cast steel gate valves are on phenol service at 60 psi., 350° F. They're on the exhaust line from extraction tower bottoms pump in the aromatic extraction unit.

Installed in 1944, these Crane valves have required only routine maintenance. Operated about twice a month—they continue to make tight closure with ease—with no leakage or sticking.

Outwardly Crane valves may look like many others. But it's a mistake to assume all steel gate valves are alike. The difference that's most important to you is inside—for instance, in the extra skill and care that goes into Crane seating design and materials. That's what makes Crane valves such outstanding performers on refinery service.

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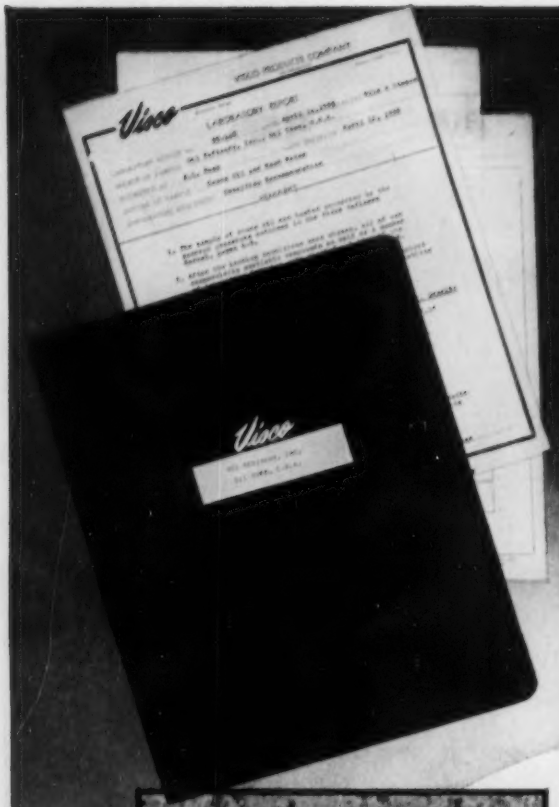

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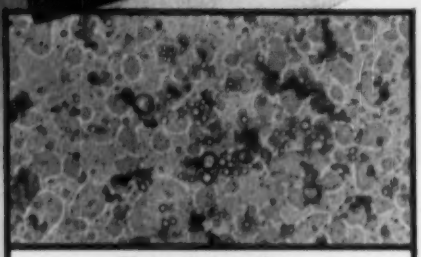
● No one knows better than you the dollar loss from a poor desalting set-up. And you know, too, there's no such thing as a blanket cure-all. But a Visco Laboratory Report *does* point the way to the results you want—from every type of crude — at no added cost to you.

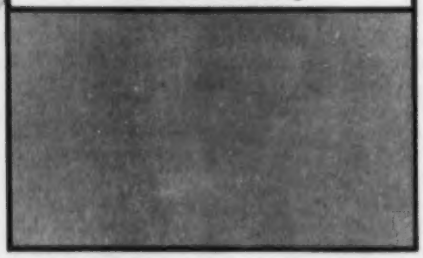
In a typical case, 20 or more separate desalting compounds and laboratory formulas may be checked and all contributing factors will be considered before the final desalting recommendation is made.

If you would like our desalting recommendation for your crude, send Visco a five-gallon can of the crude and one gallon of the water used in your refinery desalting. Or better yet, check with your Visco representative, and he will arrange for these services.



Photomicrograph—
Emulsified refinery crude

Photomicrograph—
Emulsified refinery crude
after Visco desalting



VISCO PRODUCTS COMPANY
INCORPORATED
2600 Nottingham at Kirby • Houston 5, Texas
Telephone: MAdison 3-0433

Visco® **CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS**

How To Do It . . .

$10 is paid for each accepted idea. Mail to Editor, Petroleum REFINER, P. O. Box 2608, Houston 5, Texas

Make Lifting Boom for Tractor To Handle Many Refinery Tasks

This shop-made lifting boom operated off a tractor's hydraulic lift saves time and work around a plant. Here the operator makes use of the device to move a rotor to the shop. Valves, meters, pump and turbine rotors can be handled with equal ease, and can be hauled from the operating area to the maintenance area quickly.

The boom may be fabricated from scrap material and mounted on the rear of the tractor as shown. Then when the tractor is backed up to the equipment, the boom lowered and the sling made fast, the load can be lifted and hauled away.

Automatic Blower Puts Catalyst in Regenerator

Where it is necessary to add a powdered catalyst to pick up carbon in a low-pressure gas-oil regenerator, a device may be installed beneath the tank for automatically blowing powder into the regenerator with air pressure.

To the line leading from the bottom of the storage hopper, connect a ¾-inch sight feed to a cylindrical vessel containing a rubber paddle wheel. Put a ratchet on the shaft of the rubber wheel and connect it to a crank run by an electric motor through a reduction gear. Put holes up and down the lever to adjust the speed of the rubber paddle wheel as it turns through the shaft inside the ratchet.

To the bottom of the paddle wheel

...Here's why you get

higher efficiency

from Ingersoll-Rand

MOTORPUMPS

In the final analysis, the efficiency of a pump is determined by the volume and pressure of the liquid delivered compared to the electric power consumed. And here are 4 "reasons why" Ingersoll-Rand Motorpumps give you this greater efficiency:

1. Better design of pump impellers, casing volutes and inlet and discharge passages assure maximum capacity.
2. Better foundry and coring techniques assure clean, smooth pump casings and impellers providing smooth, unimpeded liquid flow.
3. Precision machining assures accurate balance and exact clearance between impeller and casing for best performance under all loading conditions.
4. Thorough inspection assures dimensional accuracy and rigid adherence to design standards.

* For *all* the "reasons why" you get higher efficiency from Ingersoll-Rand Motorpumps in sizes from ¼ to 75 hp, write for our New Motorpump Catalog, Form 7093-E.

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9-209

How to Do It...

chamber, screw a one-inch tee. A sight glass is fitted into the line running from this tee to the regenerator. Connect an air line to the other side of the tee. The air pressure should be 10 to 25 pounds higher than that in the regenerator. Crack the valve on the air line so the powder will flow through the system at the required rate and adjust the rate of turning of the paddles with the multi-holed lever.

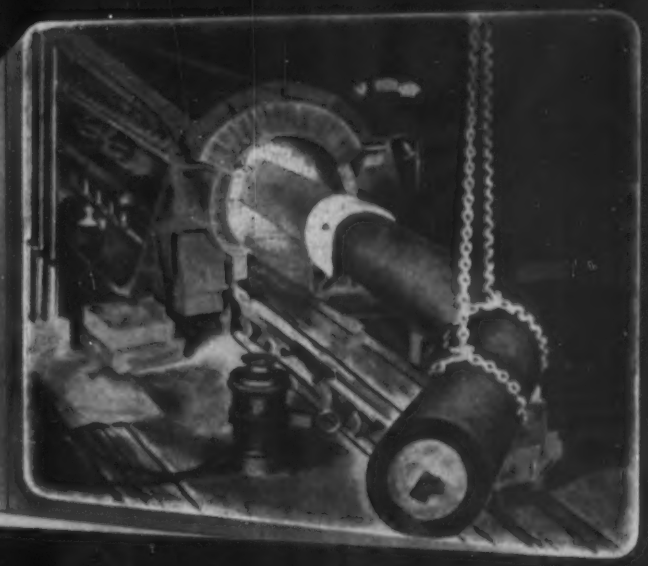
Shop-Made Bucket Stand Aids Small Parts Washing

A tripod stand for holding a wash pail saves time and effort when washing small parts in solvent. In addition, the bucket and solvent are kept handy for the next job.

The stand is made from ⅝-inch sucker rod welded as shown. Three lengths of rod, bent to the proper size, hold the bucket. The larger ring should be sized to fit just beneath the rim; the second, to fit near the bot-

Available to Company Groups and Technical Associations

INFORMATIVE!
INTERESTING!



"PREFABRICATED PIPING by GRINNELL"

A 16mm. sound motion picture, in full color. Provides an educational close-up of latest techniques in the shop fabrication of piping. Available for showing without cost.

Bending

Stress Relieving

Automatic Welding

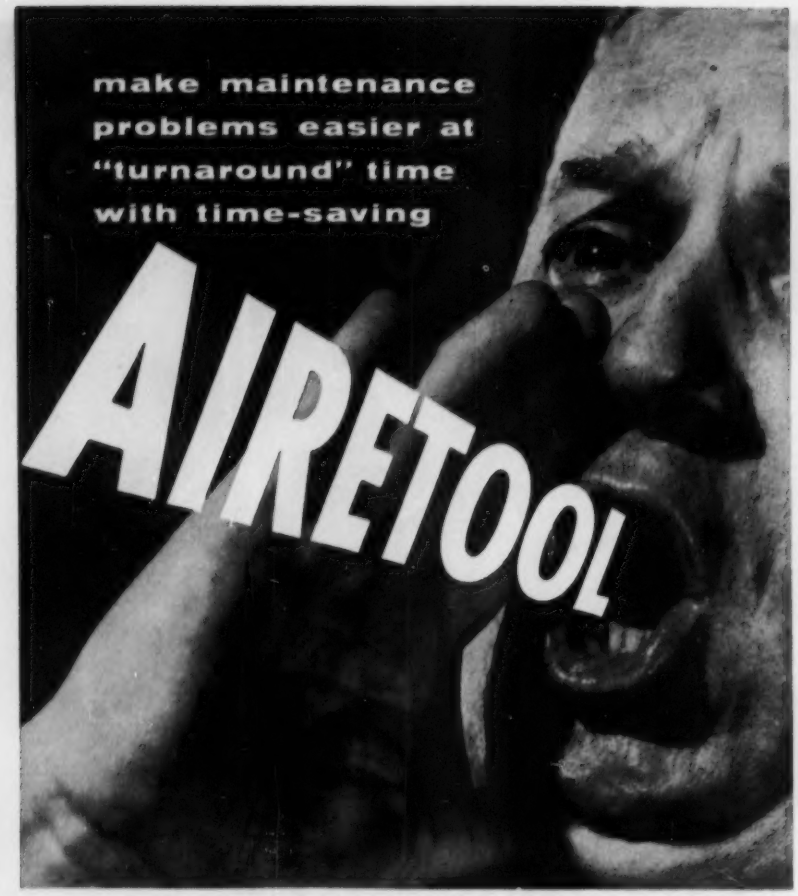
Ultrasonic Testing

"Prefabricated Piping by Grinnell" is a fascinating and factual film. Produced by the 100-year old Grinnell Company, it sheds new light on the complex subject of prefabrication of piping . . . answers with complete authority many of the questions dealing with shop vs. field fabrication.

Now you can see for yourself how the experts bend 20-inch pipe, with walls four inches thick; how pipe is sand-packed to prevent collapse in bending; how alloy pipe is pre-heated to preserve its special characteristics; how to stress-relieve after bending or welding; how to cold bend pipe; extrude branch outlets; perform automatic welding. You can look over the shoulders of the experts . . . during radiographic inspection, hydrostatic testing, and photomicrographic examination.

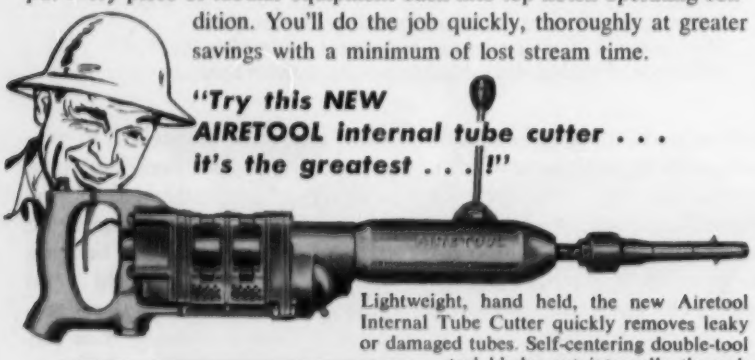
There is no charge for this film. Engineering societies and engineering departments that desire to show this picture should address their local Grinnell Supply Sales Office, or Publicity Department, Grinnell Company, Inc., 282 West Exchange St., Providence, R. I. Requests will receive prompt attention.

For more data on advertised products, use Readers' Service Cards, last page.



tube maintenance equipment

Keep your costs down and plant efficiency way up with Airetool Tube Maintenance Equipment. You can rely on Airetool equipment to remove the replacement and high expenditure headaches of turnarounds and put every piece of tubular equipment back into top-notch operating condition. You'll do the job quickly, thoroughly at greater savings with a minimum of lost stream time.



Lightweight, hand held, the new Airetool Internal Tube Cutter quickly removes leaky or damaged tubes. Self-centering double-tool steel blades cut internally through tube sheets up to 4" thick. Contact your nearest Airetool Representative for a convincing demonstration.

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

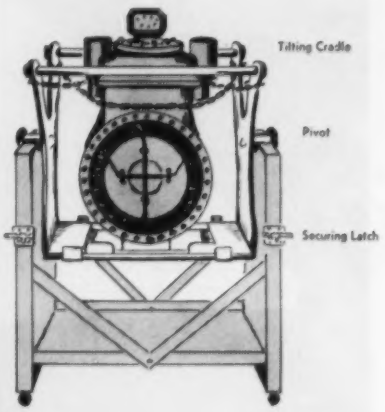
Write for literature and full information on Airetool tube maintenance equipment best suited to your needs.

BRANCH OFFICES: New York • Chicago • Philadelphia • Tulsa • Houston • Baton Rouge
Representatives in principal cities of U.S.A., Canada, Mexico, South America, England and Japan
European Plant: Airetool Nederland N. V., Vlaardingen, The Netherlands

How to Do It . . .

tom. The third ring acts as a brace. Legs are cut to a length so that top of the pail is about 30 inches high.

Inside the bucket is a removable false bottom made from 1/16-inch tinner's metal. It allows dirt to settle out of the solvent. A lid cut from tinner's metal keeps solvent clean when not in use.



Meter Repair Stand Has Safety Features

A shop-built meter repair stand will save time and provide safety in the handling of heavy meters. The stand is constructed to handle several sizes of large positive displacement meters.

Use of a pivoted cradle permits the meter to be tilted to various positions so that a repairman easily can reach all parts of the meter. Securing latches fasten the cradle in the desired working position. Chain lashing steadies the meter while it is being moved or repaired.

The stand is equipped with casters so meters may be moved about the shop. Use of the stand not only speeds repair, but reduces lifting and handling of the heavy meters, as well.

Shop-Made Check Valve May Be Worth Effort

In water systems and other noncritical auxiliary systems in a plant, the expense of check valves in large lines may not be justified. For those situations, here is a shop-made check that can do the job.

One place such a check might be used is in the line from a pump taking suction on the cold well of a cooling

this new BJ mechanical seal takes temperatures up to 800°F!

- **Proven in high temp refinery service**
- **No cold oil injection required**
- **No rotating face to sleeve gasket**
- **No stationary face to seal flange gasket**
- **Corrosion-resistant**

Here, at last, is a safe, effective answer to shaft sealing on high temperature, corrosive pumping service. This new Byron Jackson Mechanical Seal has been proved in rugged refinery service including hot asphalt and hot oil pumping (up to 800°F). It requires no cold oil injection, needs no auxiliary pumping for coolant. It is an all metal precision seal with no gaskets except shaft sleeve to shaft and seal cover to stuffingbox. New BJ High-Temp Seals are available now in any size and for any pressure encountered in refinery operation. Call your nearby Byron Jackson sales office for details or write.

You'll do better with BJ

Byron Jackson Co.
PUMP DIVISION
Since 1872
P. O. BOX 2017, TERMINAL ANNEX, LOS ANGELES 54, CALIFORNIA

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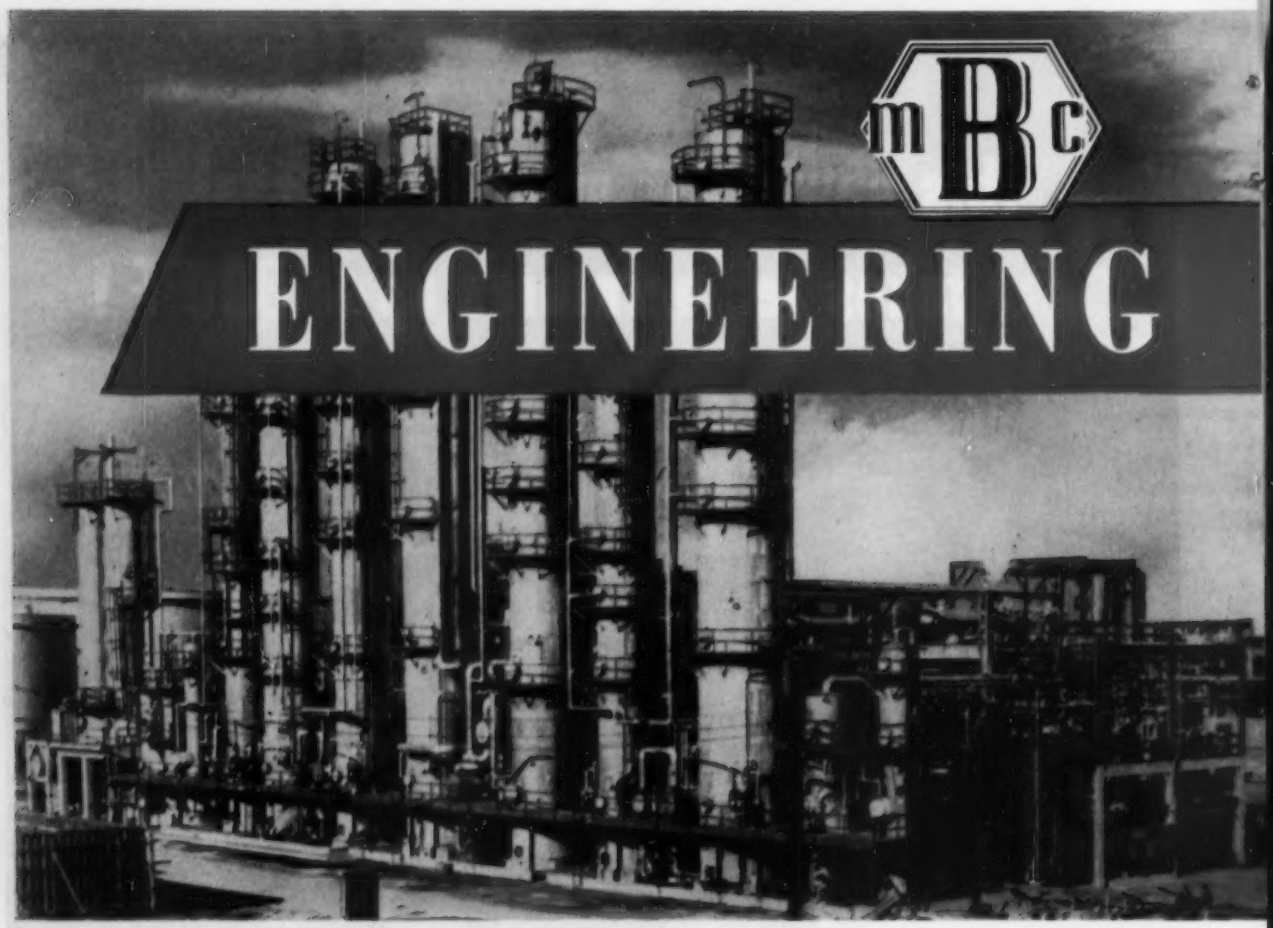
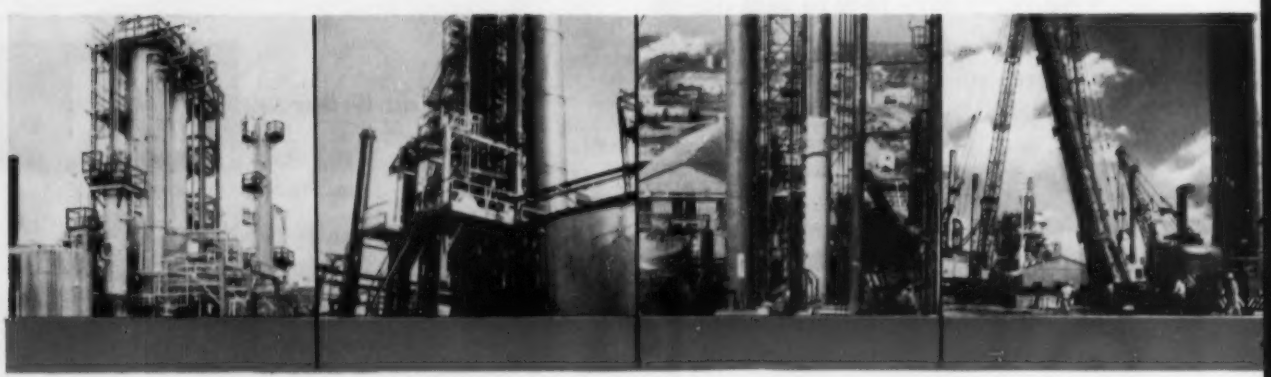


Design and Construction Service for Complete Plants and Process Units in the Broad Field of Petroleum Refining and Petrochemicals.

SINGLE RESPONSIBILITY

ENGINEERING • DESIGN • PROCUREMENT
CONSTRUCTION • INITIAL OPERATION

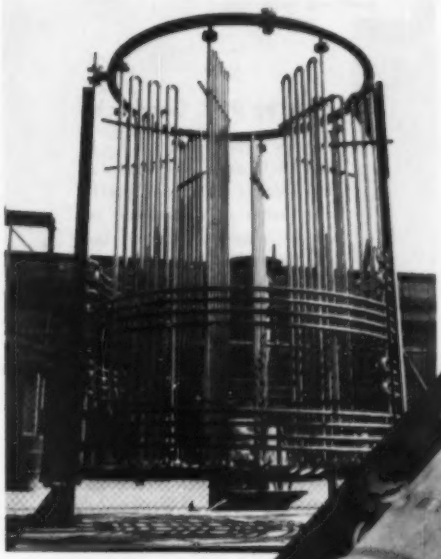


MANUFACTURING

Design and Fabricating Service

in connection with much of the Equipment called for in Plant or Unit Design Specifications, or for process equipment on an individual order basis.

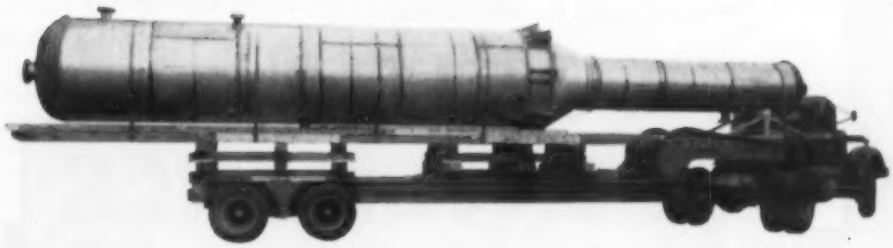
In connection with the latter, our experienced process engineers will be glad to help in the design.



Monel Coil Assembly

90 Foot Steel Column

Caps and Trays



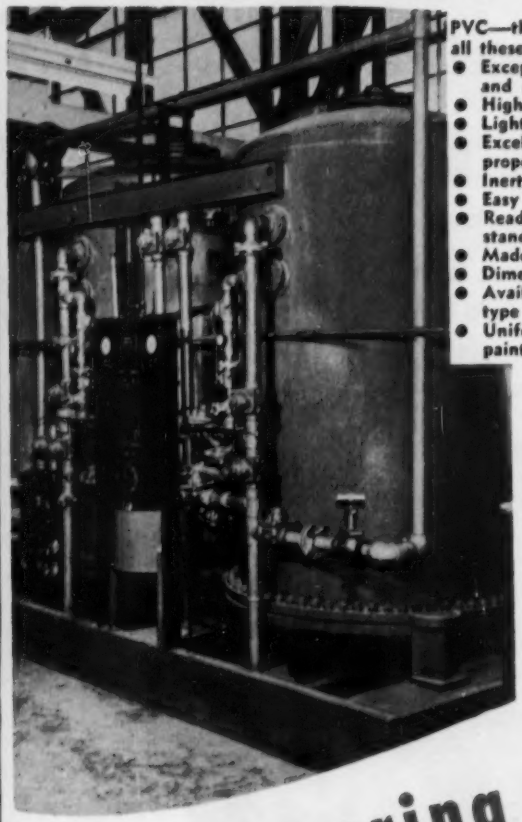
Monel Column — One Piece Construction

BADGER MANUFACTURING COMPANY

230 BENT STREET, CAMBRIDGE 41, MASS. • 60 EAST 42nd STREET, NEW YORK 17, N.Y.

POLYVINYL CHLORIDE+*

Fittings by Tube Turns Plastics, Inc.



PVC—the new, tougher plastic with all these advantages:

- Exceptional resistance to most acids and alkalies.
- High burst strength.
- Light in weight. Non aging.
- Excellent electrical and insulating properties.
- Inert. Non-toxic. Non-flammable.
- Easy to install and disassemble.
- Ready to use. Complete with standard threading.
- Made by exclusive Hendry process.
- Dimensionally accurate, uniform.
- Available both threaded and socket type for solvent or fillet welding.
- Uniform color throughout with no painting required.

Pipe by B. F. Goodrich:

A new pipe made by B. F. Goodrich does not corrode; cuts costs and practically eliminates maintenance in corrosive service. Can be installed by the same methods used for standard metal pipe.

+ Engineering Service!

REDUCE CORROSION!

MECO's long experience in the industrial field can help you in determining proper applications of PVC in piping systems for your operations: PVC's exceptional resistance to acids and alkalies can solve many of your corrosion problems. Write or phone for information.

Write or Phone
Us Your Problem

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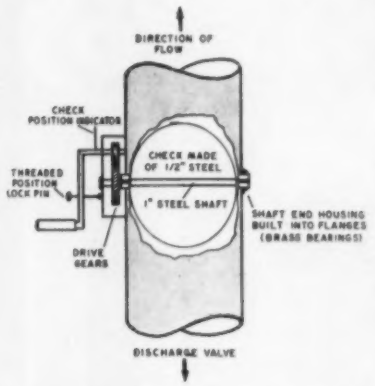
3811 CLINTON DRIVE
HOUSTON, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

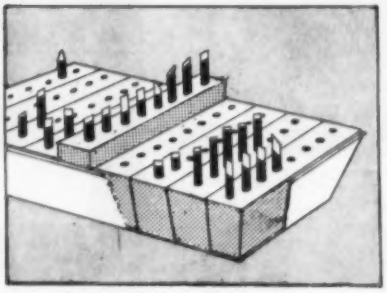
How to Do It . . .

tower. If the pump is located at approximately the same level as the water level in the cold well, a power failure could allow water from the cooling water system to back up through the pump, into the cold well



and overflow from it. If the valve on the pump discharge is a large one, considerable time may be required to close it off.

In such a situation, this check valve could be closed manually in a short time, averting the waste of cooling water. It might also be used for changing out the pump discharge valve should the occasion arise.



Make Bit Holder From Baking Pan

To be sure that lathe tool bits are easy to find when needed, make an inexpensive holder from a "dime store" baking pan and a ¾-inch board. Saw the board the width of the pan, making enough sections to fill the pan when they are placed as shown.

Drill holes in each board to hold the bits, in this case, eight in each section. Sections may be lifted out separately. Bits of particular type can be kept together in one section for convenient use.

WILL HANDLE THEM ALL!

Wedge and sealing rings molded from DuPont Teflon assure efficient, safe handling of all known industrial chemicals and corrosives at temperatures varying from −120°F. to +500°F. Spring and metal parts are furnished in the metallurgical specification best suited to the particular service. In every way, you get a mechanical seal that is "John Crane" engineered to your requirements—no matter how tough!

The Type 9 Seal has and continues to solve innumerable problems where difficult-to-handle liquids and gases are involved . . . at pressures up to 750 psi. It can do the same for you.

Use the Type 9 Seal on all rotating shaft equipment—centrifugal and rotary pumps, mixers, agitators, autoclaves, other equipment.

REMEMBER: *Your toughest problem can be the Type 9's next success story.* Send for full details today.

Crane Packing Co., 1820 Cuyler Avenue, Chicago 13, Illinois.
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JOHN CRANE CRANE PACKING COMPANY

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FIRST

IN CAT CRACKING

With over 30 per cent of all crude today eventually becoming cat cracker feed, cat cracker design is increasingly important to refiners. The superiority of the *Fluid* Cat Cracking design is well-established by the fact that 70 per cent of cat cracking capacity in the free world is the fluid design. The M. W. Kellogg Company has engineered or erected more than half of this fluid capacity.

M. W. Kellogg has been in the forefront of Fluid Catalytic Cracking from the beginning. Starting early with continuing studies of catalysts, it worked closely with the industry in engineering the fluid principle. M. W. Kellogg's contribution in mechanical engineering made it possible to design units of capacities large enough to meet accelerated demands for higher octanes since World War II. Its long experience in constructing oil refineries enabled M. W. Kellogg to undertake the erecting of these initial units, and the even larger ones in operation today, with full confidence that they would be on stream in minimum time.

An M. W. Kellogg Fluid Catalytic Cracking unit is your guarantee of many predetermined requirements, including throughput capacity, product quality and quantity, utility cost, catalyst loss, and coke-burning capacity. From its experience in engineering and erecting many side-by-side units, M. W. Kellogg originated

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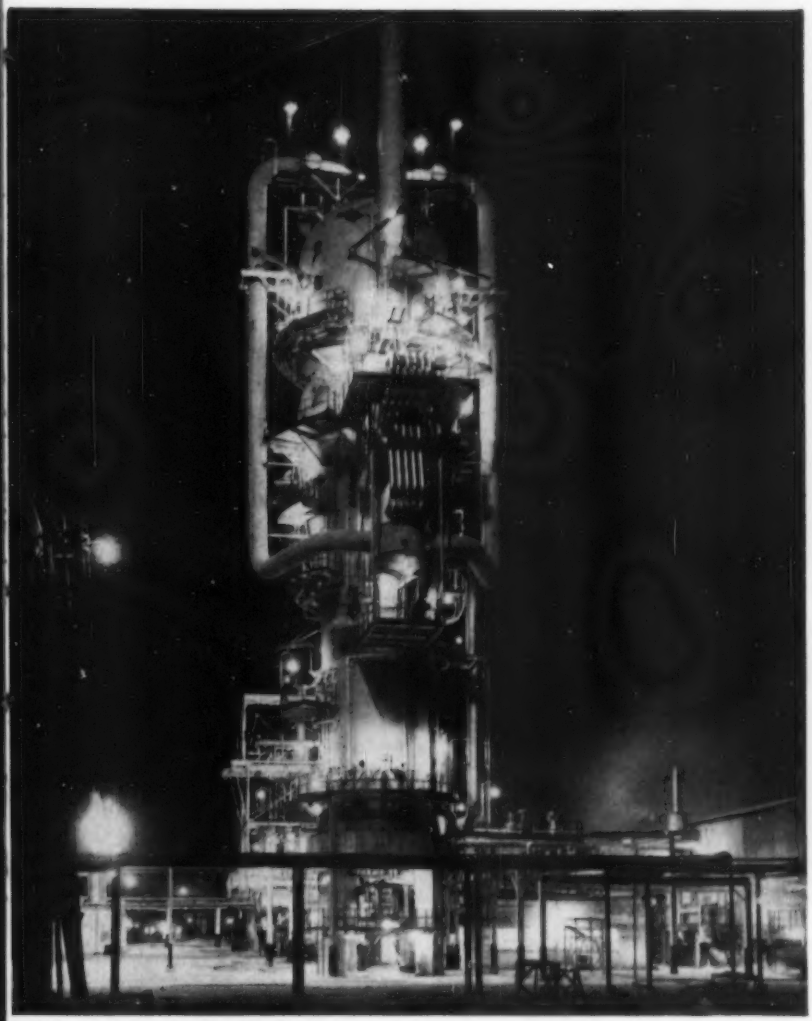

The distinctive vertical construction of M. W. Kellogg's Orthoflow Fluid Catalytic Cracker—a logical development from the side-by-side model—is becoming more and more familiar on refinery skylines. Orthoflow units completed or under construction since 1951 already represent a total throughput of over 290,000 BPD.

the straight-line Orthoflow* design—which offers many extra economic advantages.

A full-color, 13-minute movie, showing how the Orthoflow works, is now being booked for showings after July 1. Return coupon for particulars and to obtain a copy of our No. 2, 1955 Kelloggram which illustrates a recent Orthoflow installation.

Refinery Process Division

THE M. W. KELLOGG COMPANY

225 Broadway, New York 7, N. Y.

The Canadian Kellogg Company, Ltd., Toronto • Kellogg International Corp., London

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Refinery Process Division
The M. W. Kellogg Company
225 Broadway, New York 7, N. Y.

☐ **Send available dates for showing of your new Orthoflow film.**

My preference after July 1 is (1) _____ *(2)* _____

☐ **Send Kelloggram illustrating recent Orthoflow installation.**

Name _____ *(Title if any)*

Company _____

Address _____

FR-9

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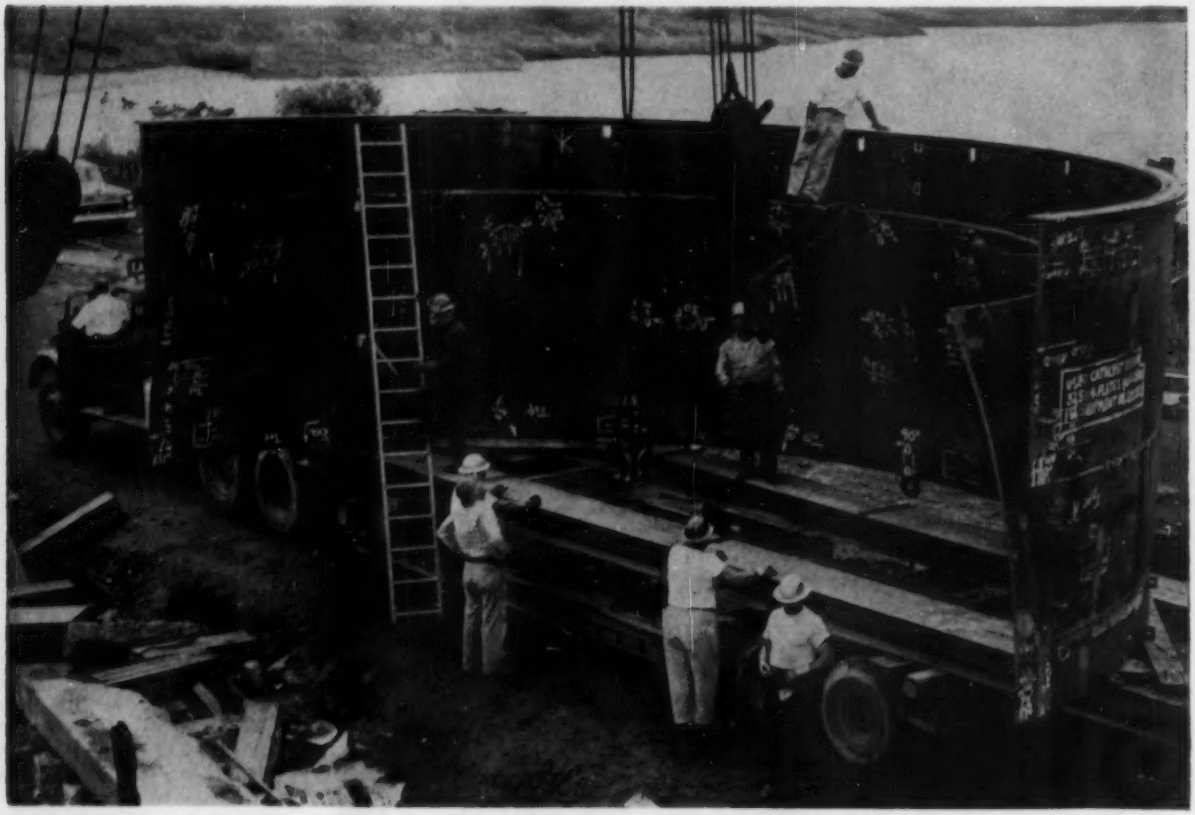
Who's Building . . .



On Last Lap of Journey—

Two huge steel parts for Tide Water Associated Oil Company's 130,000-barrel-a-day Delaware refinery are loaded on a low-bed trailer at a Delaware City pier for the last lap of their journey to the refinery construction site nearby. Too large for long overland hauling, the prefabricated sections were carried up the Delawa.e River by open-deck barge from plants in Virginia, Pennsylvania and Maryland, where they were manufactured. At the refinery site they are hoisted into place by 285-foot guy derricks and welded together to form the converter for the plant's 102-barrel-a-day Orthoflow catalytic cracker—the largest ever built.

Two Refineries Approved Before Tax Write-Offs Halted

AMONG THE LAST companies to receive rapid tax write-offs before the government tightened its rules on issuing certificates of necessity was Tide Water Associated Oil Company, cleared for fast amortization on portions of $107,270,000, for construction of crude-refining and alkylate-producing facilities at the 130,000-barrel-a-day refinery it is building at Delaware City, Del.

An Office of Defense Mobilization suspended all but one of the government's goals for expansion in the refining industry, pending a review to determine whether present facilities are adequate to meet mobilization needs. When a review of the suspended goals is completed, the goals will be either re-opened or closed permanently.

Meanwhile, there will be no further processing of pending applications for certificates, nor will new applications be received. More than 170 oil industry applications totaling $678 million were frozen by the order.

Under the tax write-off rules, an industrial project is eligible for various fasts of tax write-off over a five year period, only if it is covered by a goal for expansion that has not been

DO *YOU* TAKE GASKETS FOR GRANTED?

In the costly processes of today's industry — where fluids are confined in searing heat and brutal pressures — taking a gasket for granted is serious business. The price of gasket failure is measured in damaged equipment, plant "down-time", danger to personnel.

No one at Flexitallic has ever taken a gasket for granted. Each Flexitallic Spiral-Wound Gasket is engineered to be the right gasket for the right flange for the right seal. For 43 years, Flexitallic has worked toward perfecting this principle. Small wonder more and more engineers are specifying on orders: "Flexitallic — do not substitute".

Each Flexitallic Gasket is designed and engineered to meet specific conditions of thermal and physical shock, corrosion, vibration, weaving and unpredictable joint stresses. Spirally-wound V-crimped plies of required metal with alternating plies of proper filler result in a resilient gasket having characteristics of a calibrated spring.

Flexitallic Gaskets are at highest efficiency when bolted up cold at a predetermined load. For all pressure/temperature ranges from vacuum to 10,000 lbs., from extreme sub-zero to 2000°F. For all standard joint assemblies. In four thicknesses for special requirements: .125", .175", .250", .285". In diameters to 84" O. D.

FLEXITALLIC GASKET CO.
8th & Bailey Sts., Camden 1, N. J.
Representatives in principal cities

Flexitallic®
SPIRAL-WOUND GASKETS

FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

TEFLON FOR PROCESS APPLICATIONS

The ideal seal for many process applications is a Flexitallic Gasket with Teflon trapped between edges of stainless steel. Ask for folder, "Teflon in Flexitallic Gaskets."

*Not all spiral-wound gaskets are Flexitallic. Look for *Flexitallic Blue* —it's our exclusive blue-dyed Canadian asbestos filler.

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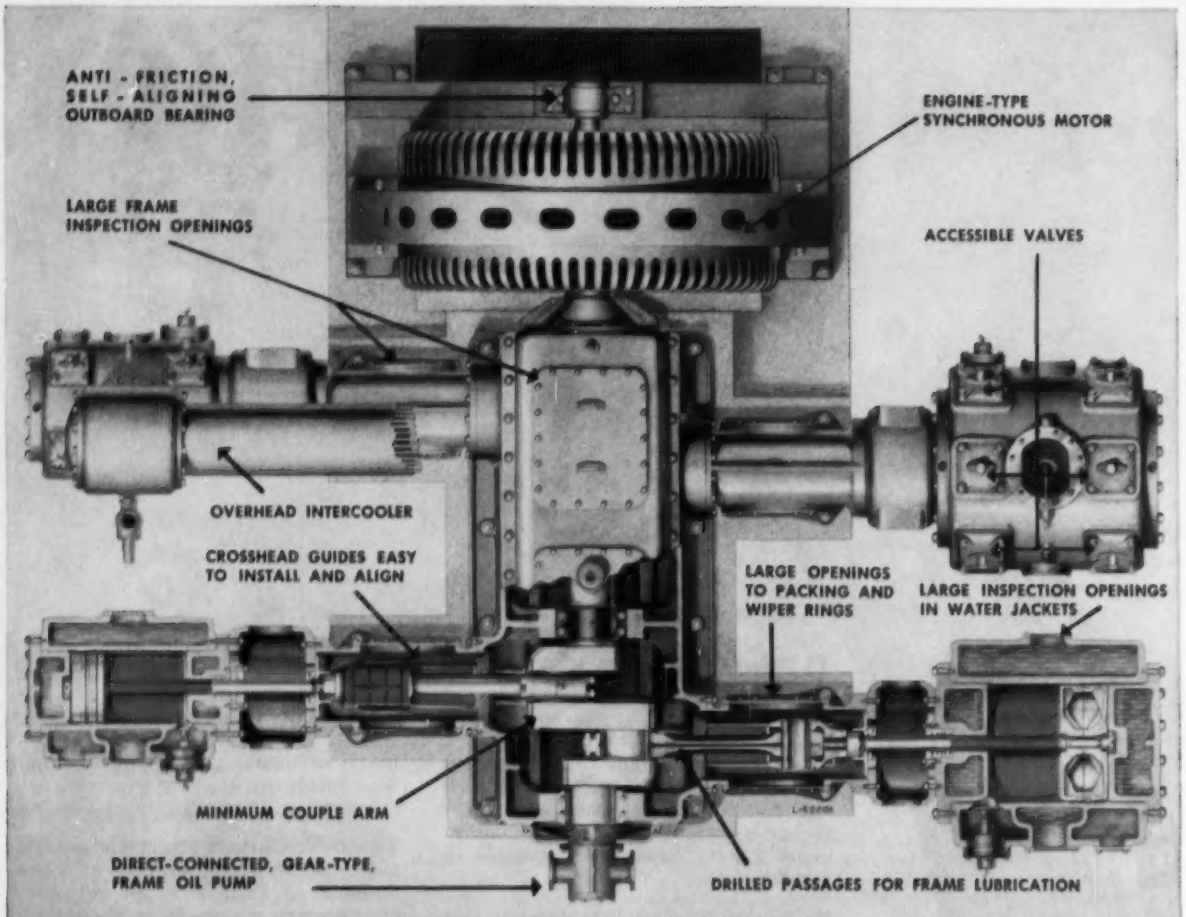
Worthington Balanced Gives LOWEST OPERATING


ANTI - FRICTION, SELF - ALIGNING OUTBOARD BEARING
ENGINE-TYPE SYNCHRONOUS MOTOR
LARGE FRAME INSPECTION OPENINGS
ACCESSIBLE VALVES
OVERHEAD INTERCOOLER
CROSSHEAD GUIDES EASY TO INSTALL AND ALIGN
LARGE OPENINGS TO PACKING AND WIPER RINGS
LARGE INSPECTION OPENINGS IN WATER JACKETS
MINIMUM COUPLE ARM
DIRECT-CONNECTED, GEAR-TYPE, FRAME OIL PUMP
DRILLED PASSAGES FOR FRAME LUBRICATION

CUTAWAY OF FOUR CYLINDER BALANCED OPPOSED COMPRESSOR. Just one of the many multi-service cylinder arrangements available. Option of drivers gives full freedom in choice of power or fuel for maximum economy and convenience. Available drivers include: direct-connected engine-type synchronous motor *(shown)*; steam turbine through reduction gear; special induction motor; or direct-coupled internal combustion engine. Red areas show lubrication coverage.

"Easier to inspect and maintain than any similar compressor." That's what engineers say about the Worthington Balanced Opposed Compressor.

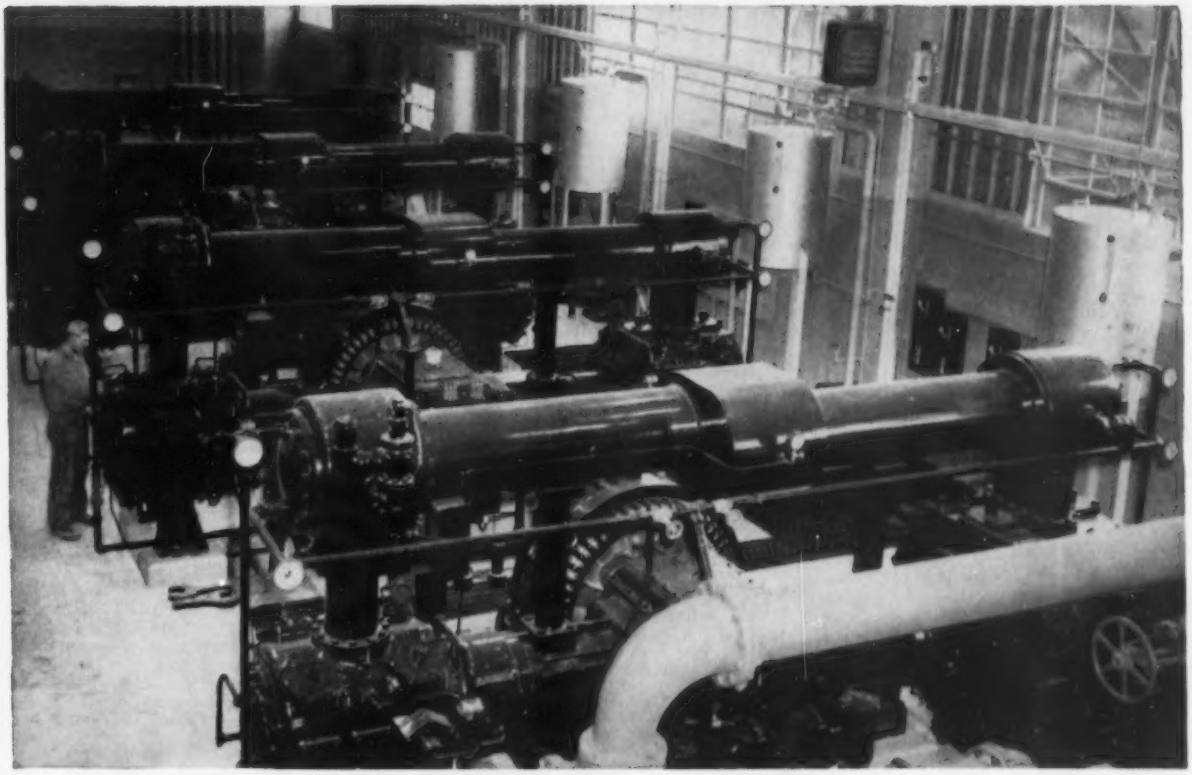
LARGE ACCESS OPENINGS are provided for inspection and maintenance of piston rod packing, oil wiper rings, water jacket, main bearings, crossheads, and crosshead guides. All valves are accessible and easily replaced. This easy accessibility of working parts facilitates *preventive* maintenance, reduces downtime for *corrective* maintenance.

REDUCED INSTALLATION COSTS because foundations can be smaller. Inertia forces developed in one cylinder are bucked and largely cancelled out by similar and opposite forces developed in the opposing cylinder. Only a relatively small turning force, or couple is transmitted to the foundation. As a result, foundations are smaller for the balanced opposed than for equally rated compressors of other designs.

MAXIMUM STRENGTH, MAXIMUM STABILITY, result from the rugged one-piece-cast main frame and most stable construction of any similar compressor. Main bearing supports are integral with frame and reinforced with heavy steel tie bars over each bearing. Keyways in frame seat each tie bar and lock it in place, permanently preserving alignment.

AVAILABLE SIZES AND TYPES range from 300 to 10,000-hp with pressures from vacuum to 35,000 psig. A few applications include (figures indicate orders of magnitude only): *dry vacuum pumps* operating at very low pressures, *standard shop air compressors* (125 psig), *refrigeration gas compressors* (250 psig), and *multi-stage gas compressors* for use in service such as ammonia synthesis, methanol and hydrogenation plants (3500 to 35,000 psig). For more information, write for Bulletin L-679-B1 on company letterhead. Worthington Corporation, Section K.5.2, Harrison, New Jersey.

Opposed Compressor Design and MAINTENANCE COSTS



COMPRESSED AIR for Ford plant in Mahwah, New Jersey, is supplied by this array of four 450-hp, 100 psig Worthington Balanced Opposed Compressors.

HIGH-SPEED, LOW INERTIA Worthington Feather® Valve contributes to quiet operation and easy maintenance of Worthington Balanced Opposed Compressor. Thin, flexible strips of stainless ribbon steel form active elements. Curved guards hold strips in position over rectangular openings. Strips lift and flex uniformly against guards. Absence of impact results in quiet operation, longest valve life and low maintenance costs.

WORTHINGTON

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Who's Building...

filled. The suspension of goals thus ended the application of rapid-tax amortization to virtually all oil and gas projects.

The only petroleum goal remaining open is a 30,000-barrel-a-day capacity for alkylate. Of the total allowance granted Tide Water, $7,200,000 is for alkylation facilities.

Tide Water, however, will be allowed to write off construction of its new plant at the fast rate of 65 percent on $57,400,000 and 40 percent on $42,670,000 for crude-refining facilities at Delaware City, together with 40 percent on $820,000 and 100 percent on $6,380,000 for alkylation facilities.

Beaumont Plant Approved

Another company which managed to get its application approved just before the suspension became effective is Aviation Fuels Company, planning to build a new refinery at Beaumont, Texas. The company was issued certificates on a total of $24,070,000 for new construction.

It will be allowed to write off at the fast rate of 100 percent on $11,924,000 for special facilities; 65 percent on $4,460,000 for basic plant; 40 percent on $4,850,000 for auxiliary equipment; 50 percent on $2,500,000 for utilities, and 15 percent on $286,000 for buildings.

The new Beaumont refinery will include an 8000-barrel-a-day topping and cracking unit, a 2600-barrel-a-day isomerization unit, a dehydrogenation unit designed for 4500 barrels a day and an alkylation unit rated at 5200 barrels a day.

Closes 19 Categories

The government's order ended fast tax write-off allowances for 19 categories of industrial expansion and indefinitely suspended allowances for 38 other categories. This leaves open for quick amortization only 20 categories of production facilities directly related to defense or atomic requirements.

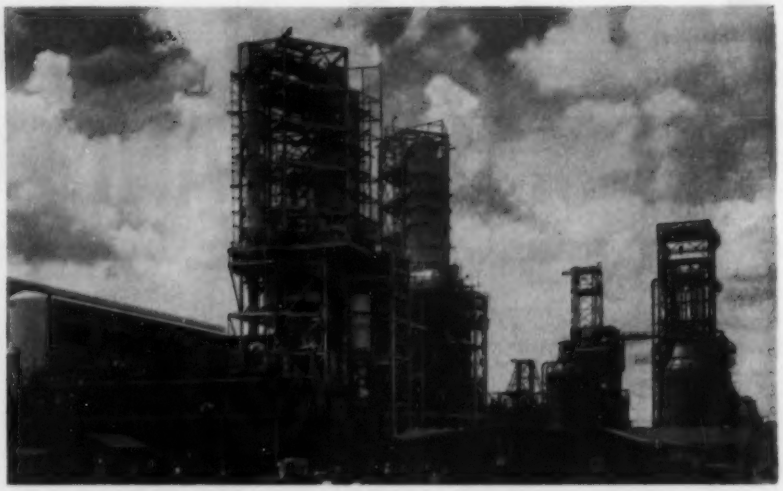
The action was ordered by Defense Mobilizer Arthur Flemming to permit a review of U. S. industrial mobilization capacity. All the suspended goals covered "defense supporting" facilities such as petroleum refining.

A Stimulus to Building

The government has issued fast write-offs to stimulate industrial capacity to turn out defense-supporting goods. A plant operator who received a certificate was permitted to deduct the cost of his new facilitiy from his income tax at a rate faster than normally permitted by the government.

This had the effect of cutting his income tax payments during the early years of the operation of the new facility and enabled him to finance his expansion more easily.

A group of top government policy makers have been studying the tax-amortization program several weeks to determine whether it should be sharply curtailed. The study was touched off by Treasury Secretary George Humphrey who called the fast write-off "an artificial stimulus of a dangerous kind."



Largest Oxygen Plant Nearly Finished—

The world's largest oxygen plant, at Brownsville, Texas, was undergoing final revamping prior to the start of operational tests. The plant is an integral unit in the Brownsville chemical operations of Stanolind Oil and Gas Company and its subsidiary, Hidalgo Chemical Company. Its production of oxygen will be mixed with natural gas in a modified Fischer-Tropsch hydrocarbon synthesis process. Other sections of the operation will start up later in the year. Start-ups of the units will be scheduled in sequence of their function in the operating process. The first production is scheduled to start about the first of the year. The utilities section of the gas-synthesis plant, including electric power and steam, was being placed in operation. The Lummus Company is prime contractor on the reconditioning program.

Getting Ready to Start—

Like the parts of a giant's "Do-It-Yourself Kit," the steel sections of the 250-foot Orthoflow "cat cracker" converter column lie about the construction site of Tide Water Associated Oil Company's 130,000 barrel-per-day refinery, under construction at Delaware City, Del. The tall structural steel platform in the background is merely a temporary structure on which will be mounted a 220-foot derrick. The latter will be used to hoist the converter's sections into place. The crane at right is aligning the steel sections so that welders can assemble them before they are hoisted. The markings scrawled on the steel shell at the extreme right are assembly instructions to the workmen.

Planning—

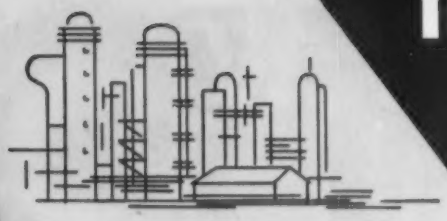
Cosden Petroleum Corporation will add a 3868-barrel-a-day Rexformer to its refining equipment at Big Spring, Texas. The unit will produce a 98 F-1 clear-octane blending component for use in upgrading gasoline. The blending material now is being produced in a Platformer, which will be converted to prepare aromatic feed stock for an integrated Udex unit.

Straight-run gasoline derived from crude distillation, natural gasoline and miscellaneous butane and pentane fractions will be charged to a five-tower prefractionation section which will produce feed stock for the Rexformer, as well as Platformer feed stock to produce benzene, toluene, xylenes, butanes, isopentanes and normal pentanes used in producing aviation gasoline.

Cosden also is building, with refinery personnel, a 1600-barrel-a-day Unifining

Finest

IN THE FIELD



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'American-Microsen' Electronic Process Control Installations Now In Successful Operation Have Proved The Reliability, Speed, Sensitivity And Accuracy Of This Modern Concept Of Process Instrumentation.

This is the electronic process control system that now makes it practicable to utilize the capabilities of process equipment far more fully than ever before. Revealed in actual operation of plant-scale installations are the much discussed benefits of this new approach to plant instrumentation.

Used to *measure, indicate, record and control process variables* (pressure, differential pressure, temperature, liquid level, flow, pH, gas analysis, etc.), these installations exhibit every essential to improve product quality, increase operational efficiency and plant productivity.

Only the 'American-Microsen' System provides:

Lag-free signal transmission using the simplest communication lines.

Extremely fast, accurate measurements and control responses — sensitivity impossible to duplicate in other types.

Installation of all controllers in the instrument room *any distance from the process* — even 30 miles or more.

High stability that permits use of narrower proportional bands.

Freedom from dirt, leakage, freeze-ups and other transmission line problems.

Standardized control components interchangeable at the panel and plug-in components on each instrument.

Adaptability — more than one input circuit can be fed into a controller for cascading or programming.

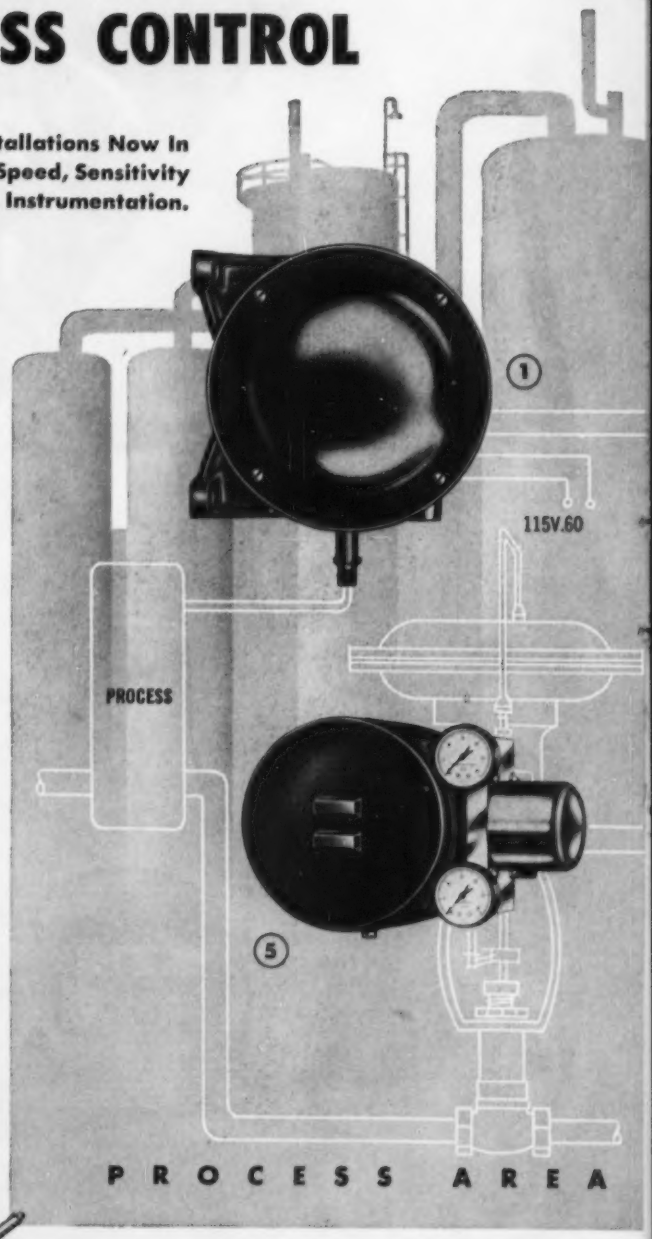
DC signal that can be fed to potentiometer recorders, digital read-out systems, monitors, computers, etc., so that process and operational data are automatically reduced to quickly usable form.

Flexibility — output signal can be fed in series to any number of receivers, without impairing accuracy. Components can be mounted anywhere convenient to operating and servicing.

Electrical circuitry makes possible unusual control and measurement functions not available in mechanical systems.

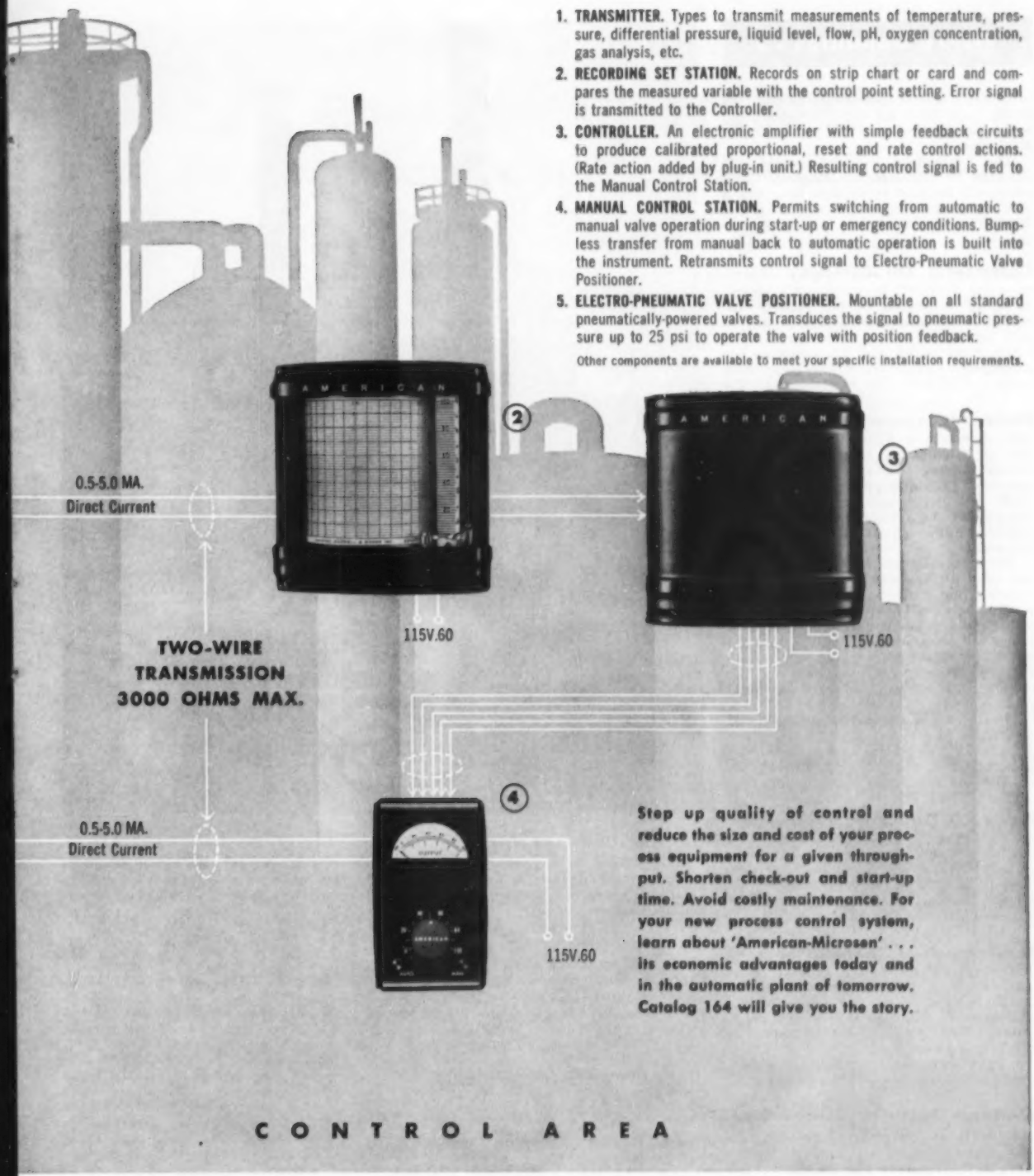
Minimum installation or maintenance investment in transmission lines, air compressors, filters, pressure regulators, dryers.

**Names and locations of installations available upon request.*



THE 'MICROSEN' BALANCE, the "nerve center" of 'American-Microsen' instruments, is a simple, electro-mechanical servo-mechanism. It operates on the force-balance principle to produce a high-level direct current signal that is not affected by any normal electrical or ambient condition.

MANNING,



1. **TRANSMITTER.** Types to transmit measurements of temperature, pressure, differential pressure, liquid level, flow, pH, oxygen concentration, gas analysis, etc.
2. **RECORDING SET STATION.** Records on strip chart or card and compares the measured variable with the control point setting. Error signal is transmitted to the Controller.
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For more data on advertised products, use Readers' Service Cards, last page.

unit which will be used to desulfurize part of the feed stock for the Platformer, and to furnish part of the feed stock for the Rexformer.

The Rexformer, being engineered and designed by Universal Oil Products Company, will be built by Procon, Inc., and is due to go into operation during spring 1956. The Unifiner is due to go on stream shortly.

Continental Oil Company expects to spend $500,000 in additional modernization of its Artesia, N. M., refinery. Included in the company's program will be the installation of a 1500-barrel-a-day catalytic-reforming unit. The company has scheduled construction for completion early in 1956.

Standard-Vacuum Oil Company will undertake a $20-million modernization of its oldest and largest refinery—the Sungei Gerong plant near Palembang, Sumatra. The improvements, due to take about two and a half years to complete, are part of the company's four-year $80-million capital investment program in Indonesia.

The modernization will include installation of a 10,000-barrel-a-day (feed rate) recycle Fluid catalytic cracking unit and an 1100-barrel-a-day (product output rate) non-selective catalytic-polymerization plant which will transform light gases into high-octane naphtha for upgrading motor gasoline. Existing process equipment will be revamped to increase individual unit thruput.

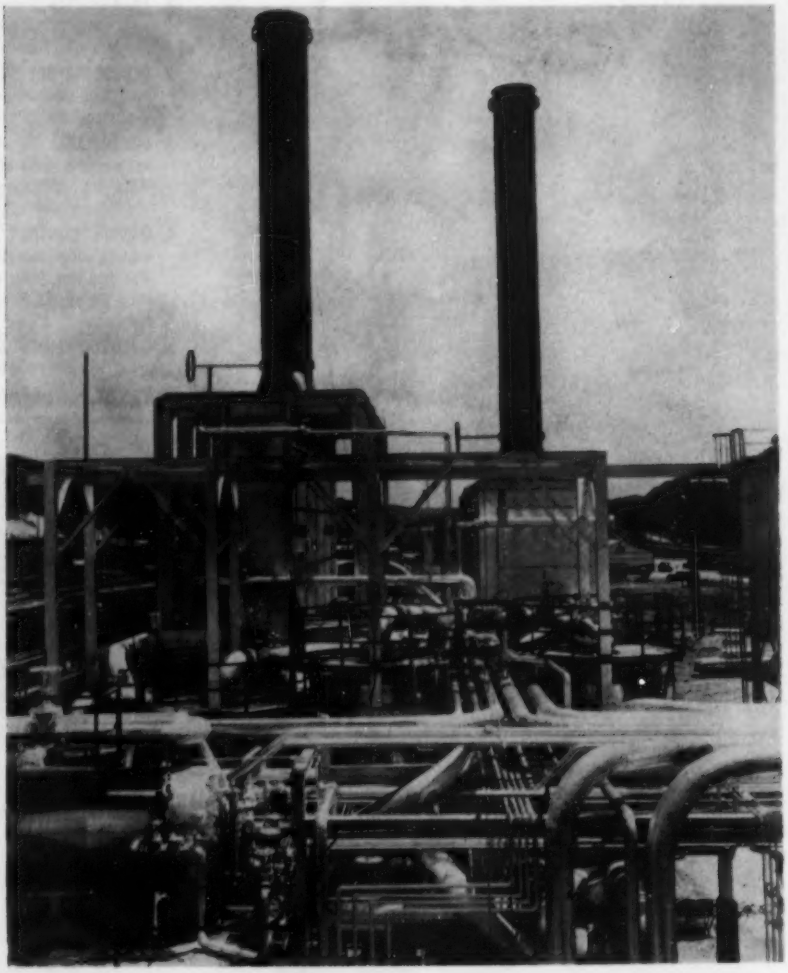
Already being installed are additional generating facilities, and bids are being received for a new sulfuric-acid plant. The refinery is owned and operated by Standard-Vacuum Petroleum Maatschappij.

Skelly Oil Company, purchaser of a Lea County, N. M., natural-gasoline plant, will increase the installation's daily capacity to 14 Mmcf. The plant, bought from Otha H. Grimes of Tulsa, is designed to process 7.5 Mmcf. of gas a day, extracting gasoline, butane and propane.

Government of Thailand plans to build a 5000-barrel-a-day refinery near Bangkok. Some one-third of the plant's capacity would be geared to producing gasoline, with 15-25 percent of the yield going for bunker oil and 15-20 percent for diesel oil. Aviation gasoline, aviation turbofuel, kerosine, asphalt and liquefied petroleum gas also are proposed for production.

Goodyear Synthetic Rubber Corporation, planning a 50 percent expansion of the copolymer plant it recently acquired in Houston, will enlarge its facilities in two stages. When the first project is completed early in 1957, plant capacity will be stepped up from its present 137,500 tons a year to 170,000 tons. Later construction is due to increase annual capacity to more than 200,000 tons.

Cia. Petrolera Shell de Cuba is scheduling construction of a new refinery at Havana. The $19-million plant, to be built by Bechtel Corporation, is due to go on stream in November, 1956. Process equipment will include crude distillation, a Platformer and ancillary units.



New Ashland Unit on Stream—

Ashland Oil & Refining Company has placed a new 6000-barrel-a-day catalytic-reforming unit on stream at its refinery in Catlettsburg, Ky. The new facility, a Houdriformer installed by Catalytic Construction Company, is designed to take a full range of naphtha charge for upgrading gasoline.

Esso, A. G., West German subsidiary of Standard Oil Company (New Jersey) and one of Germany's largest crude-oil refining companies, has plans to build a new refinery with an annual production capacity of 3 million tons. Both the Hamburg area and the Rhine-Ruhr district are under consideration as possible sites for the new plant.

The El Dorado Refining Company will spend an additional $750,000 in its current expansion program for the construction of a catalytic reformer at its refinery in El Dorado, Kan. The new unit will be a Platformer with a charge capacity of 2500 barrels a day. It will be capable of producing up to 100 octane gasoline.

Construction was scheduled to start early this month. The work is being handled by El Reco personnel with the use of local sub-contractors. The Platforming unit will be erected adjoining the plant's new catalytic-cracking unit, also designed and licensed by Universal Oil Products Company.

Northwest Nitro-Chemicals, Ltd., will erect a $22-million petrochemical plant at Medicine Hat, Alba., for making ammonia, ammonium nitrate, ammonium phosphate, and nitric and sulfuric acid. Contracts were let for units of the new ammonia plant. Completion is scheduled for late 1956.

The company, owned by Commercial Solvents Corporation and New British Dominion Oil Company, Ltd., selected Canadian Kellogg Company to build the ammonium nitrate, ammonia, sulfuric-acid and nitric-acid units. The Fluor Corporation of Canada will build the phosphoric-acid unit, and the prime contractor, Ford, Bacon and Davis, will build all off-site facilities.

Cities Service Oil Company (Del.) plans to spend up to $5 million in the coming year on new construction and enlarging its Ponca City, Okla., refinery.

Design work is underway on a 6000-barrel-a-day Rexforming unit, and plans include revamping the crude-vacuum unit to make a naphtha feed-stock cut for the

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New Houdresid Process Completely Cracks the Bottom of the Petroleum Barrel, Increases Gasoline Yields.

The Houdry Process Corporation has announced an economically feasible process for catalytically cracking the bottom of the petroleum barrel. The new process, named *Houdresid*, converts reduced crudes into the most desirable refinery products.

Houdresid eliminates the need for expensive feed preparation processes. It also accomplishes a marked increase in gasoline yield; approximately 64 per cent gasoline is produced from the residuum as compared with 52.5 per cent gasoline yield from vacuum distillation plus catalytic cracking.

The Houdresid Process has been on stream for more than a year at the Sun Oil Refinery at Sarnia, Ontario.

For further information write to: Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Pennsylvania.

HOUDRY PROCESS CORPORATION

PIONEER IN CATALYTIC PROCESSES

New Houdry Iso-Plus Process Reforms Low-Octane Naphthas Into 100-Octane Plus Gasoline

The new Houdry Iso-Plus Process reforms run-of-the-refinery low-octane naphthas into gasolines with octane ratings as high as 108-octane F-1 clear.

Conversion rates are extremely high. Variations of the Iso-Plus Process yield from 86% to 91% of naphtha charge stock into 100 octane gasoline. Up to 82% of the charge stock can be converted to 108 F-1 clear octane gasoline for blending with refinery pool gasolines of lower anti-knock ratings.

The development of Houdry Iso-Plus gives refiners a conclusive answer to the present high octane derby. With 300 h.p. automobile engines predicted for 1960, refiners are now planning their process facilities for the economical production of suitable fuels. Houdry Iso-Plus, already extensively tested in the pilot stage, can meet all high-octane requirements of the foreseeable future.

For further information, write to Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Pennsylvania.

HOUDRY PROCESS CORPORATION

PIONEER IN CATALYTIC PROCESSES

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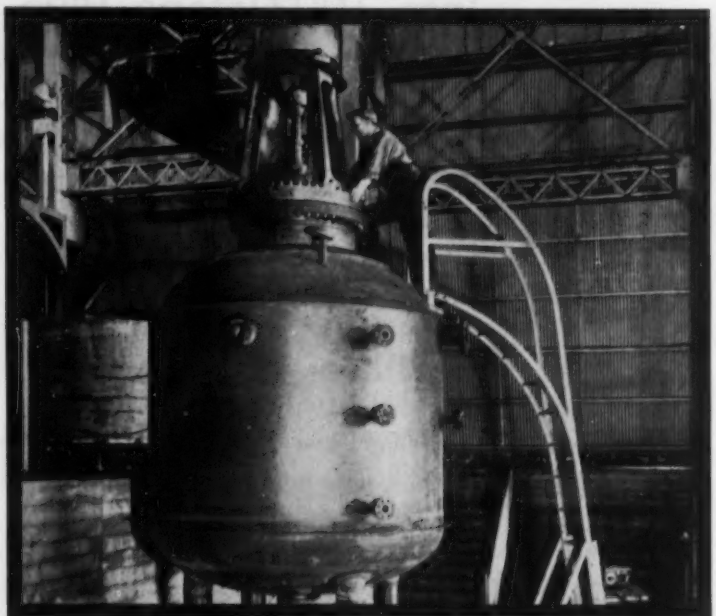

Turbo Contactor For Butane Isomerization: *furnished to C. F. Braun & Co., Engineers and Constructors as part of a plant built by them in 1942 for a West Coast petroleum processor.*

For over 25 years, Turbo has supplied leading oil companies with precision-built mixers for petroleum processing. In many plants, the original Turbos are still in operation—after more than 20 years of continuous 24-hour maintenance-free service. This outstanding service record is a testimonial to the rugged design built into each and every Turbo. If you have a process problem, call on Turbo. A Turbo engineer is always available to work with your engineers on request.

***How the petroleum industry uses Turbo-Mixers**—Asphalt filling, asphalt oxidation, asphalt cut back blending, spent doctor oxidizing, doctor treating, drilling mud mixing, lube blending, solvent extraction and many others.

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Who's Building...

Rexformer. The company also intends to increase the plant's crude-processing capacity from 25,000 barrels a day to 30,000 barrels.

Gasolines with a clear octane number in excess of 100 have been produced by the Rexforming process in laboratories operated by Universal Oil Products Company, developer of the process. The unit being designed for Ponca City will process low-octane naphthas, recycling the un-reformed naphtha until the desired octane number is obtained.

Construction work will get underway early in 1956, and the Rexformer is due to be completed early the following year. Engineering will be handled by UOP and the unit will be built by Procon, Inc.

Goodrich-Gulf Chemicals, Inc., plans to build a pilot plant in northern Ohio to produce a new synthetic rubber. The plant is expected to be in operation in less than a year. The company, owned jointly by The B. F. Goodrich Company and Gulf Oil Corporation, previously announced that its scientists had developed a process to reproduce the molecule of crude rubber. It claims the new rubber is physically and chemically identical to tree rubber.

Eleonora Chemical Corporation will build a polyvinyl-chloride plant at Passaic, N. J. The company is a recently-organized subsidiary of Pantasota Company. Scientific Design Company, Inc., will handle engineering and construction.

Tennessee Eastman Company will build a hydrogen plant at Kingsport, Tenn. The plant, to be erected by Bay Mountain Construction Company and Tennessee Eastman personnel, will be completed early in 1956. The Girdler Company will engineer the plant and supply equipment.

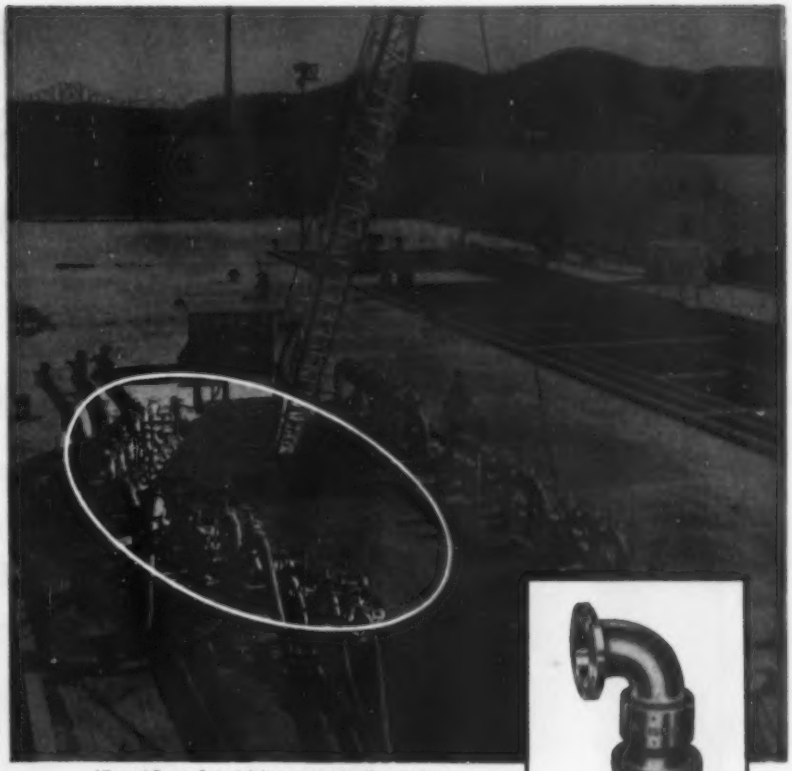
The new plant will use a steam-hydrocarbon reforming process with natural gas as feedstock. It will be designed to use LPG as a raw material for both process and fuel requirements if the supply of gas is temporarily interrupted.

Reforming will be accomplished in a single multi-tube reformer furnace followed by two stages of carbon-monoxide conversion and carbon-dioxide removal. Final purification will be accomplished by a methanation stage which will produce hydrogen with a purity greater than 99.5 percent.

Creole Petroleum Corporation will expand its Amuary, Venezula, refinery to boost thruput by 100,000 barrels a day, bringing the plant's total thruput to 260,000 barrels.

Magnolia Petroleum Company has scheduled a six-project construction program to start this fall at its refinery in Beaumont, Texas, bringing the cost of expansions planned for that plant to an estimated $25 million. The major part of the expansion will be additional facilities to manufacture high-octane gasolines and distillate products.

Included in the program are previously announced plans for equipment to process butanes and propanes for marketing as liquefied petroleum gas and for use in gasoline blending. One of the projects in-



View of Emsco Swivel Joints on one loading station.

Emsco 8" type LP Swivel Joint Style 2 with flanged ends for loading dock service.

EMSCO SWIVEL JOINTS SELECTED FOR NEW LOADING WHARF

We are proud to have supplied the Swivel Joints installed on this loading wharf making it one of America's newest and most modern loading facilities. Here are installed a score of Emsco 6" and 8" type LP Swivel Joints. Free turning and easy maintenance were prime factors in the selection of Emsco for this job. In the cross section note how the thrust load is absorbed through the ball bearings – how easily bearings can be adjusted. Note also how readily the packing can be replaced simply by separating the joint as one would a union. No return of joint to the factory for service. Emsco assures you a new kind of dependability in Swivel Joints.

Emsco's complete line includes Swivel Joints for high or low pressure, high vacuum, corrosive or high temperature service; for gas, liquid or semi-solids. Check with us or our field representatives. Over 500 various combinations to choose from. Sizes ⅜" to 12". Pressures to 15,000 lbs. Temperatures to 750° F.

Simplicity of Emsco's patented design assures a new kind of performance and dependability in Swivel Joint construction.

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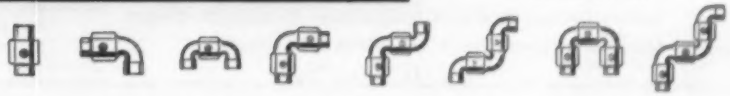

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Bingham

DOUBLE VOLUTE DOUBLE CASE "HI-PRESS" PUMP

UNSURPASSED

FOR EXTREMELY HIGH PRESSURES

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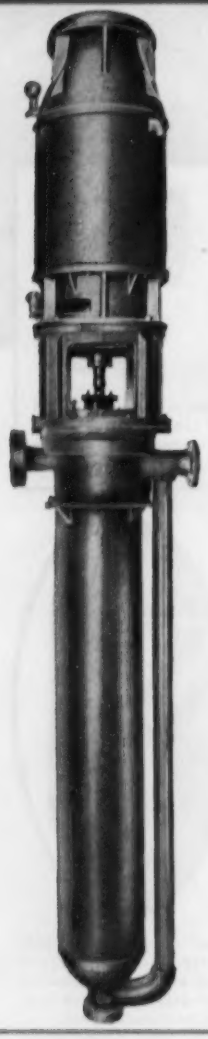


"DOUBLE VOLUTE" DESIGN PROVIDES HYDRAULIC RADIAL BALANCE OF ROTATING ELEMENT... NO "SIDE PUSH"... ELIMINATES WEAR AND SEIZURE

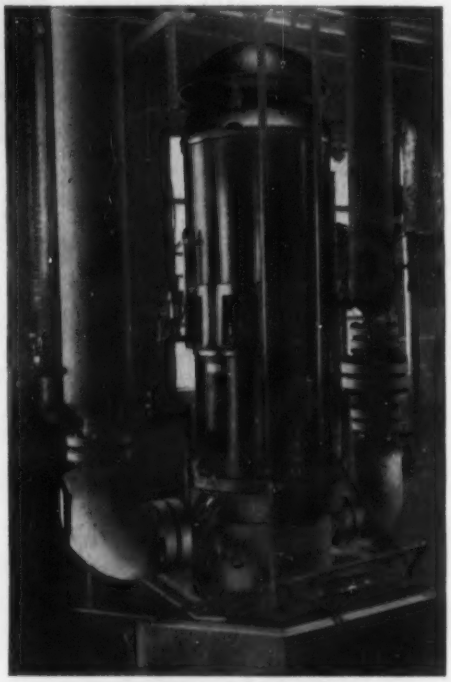
The "Double Volute" construction of Bingham Multistage "Hi-Press" Pumps insures perfect radial balance of the rotating element, under all operating conditions... completely eliminating wear between rotating and stationary parts. "Double Volute" construction permits maximum use, without exceeding normal clearances, of non-corrosive metallurgy—particularly austenitic steels—normally considered dangerous on account of their galling and seizing characteristics.

This feature also eliminates shaft deflection, permitting **mechanical seals** to establish and maintain a uniform track between contacting faces. This prevents leakage and seal face wear, resulting in **long seal life.**

"Double Volute" design also permits the pumpage to be discharged from the inner into the outer case through *two nozzles* located 180° apart. For hot service, this feature provides adequate circulation of pumpage between the two cases, insuring a uniform temperature rise in all parts—thereby eliminating distortion due to temperature changes.

Location of suction and discharge at top of pump case is particularly suitable for low NPSH conditions.

Bingham "Hi-Press" Pumps have established an exceptional record of long life and trouble-free service wherever they have been installed.



One of a group of Bingham "Hi-Press" Pumps in a large East Coast refinery handling 750° F. reduced crude oil at a differential head of 2000 feet.

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Who's Building . . .

volved, a Thermofor catalytic-cracking unit, will be the largest of its kind ever built. A Sovaformer unit, also included, will be the first such process in the Southwest.

The Sovaformer is scheduled to process 20,000 barrels of naphtha a day. The Thermofer unit, the fifth of its type built at the Beaumont refinery, will be rated for a daily capacity of 28,000 barrels.

Also included in the program is a vacuum flash tower to break out gas oil stocks for the new cracking unit from crudes already reduced in other processes. It will be an addition to the refinery's existing combination unit, enlarging that unit's structural site by about a third. The other three projects involve expansion of the plant's TCC facilities.

All six projects are to be built concurrently. Design work is in progress, and the new equipment is expected to be in operation in the fall of 1956.

Phillips Chemical Company has plans to expand by 15 percent its newly-acquired Plains copolymer plant near Borger, Texas. Construction of new facilities are scheduled to start immediately and is expected to be completed by September 1956.

The copolymer plant and adjacent butadiene plant were recently purchased from the government. Phillips previously had operated the facilities under a contract with the government.

Cosden Petroleum Corporation will begin construction on an 18-million-pound-a-year styrene plant at its refinery in Big Spring, Texas. The new installation, expected to cost $2,850,000, will use raw material from the refinery's existing aromatics plant. The styrene unit is scheduled for completion by mid-1957.

Continental Oil Company has scheduled $1 million to be spent for expansion of its refinery at Billings, Mont. Construction, being handled by Stearns-Rogers Manufacturing Company, includes installation of new gasoline reforming and desulfurization equipment. The project is due to be completed in early 1956.

Government of Iraq has awarded a contract for design and construction of a complete lubricating-oil refinery. The new plant will produce 25,000 tons of lubricants a year. The contract went to Foster Wheeler, Ltd., England.

Processing units will include vacuum distillation, propane deasphalting, furfural refining, propane dewaxing, clay percolation and acid treating. The contract also calls for a drum- and can-making plant with filling facilities, water-treating facilities, a cooling tower, tankage and general off-site facilities.

Union Oil Company of California is planning an expansion of its Edmonds, Wash., asphalt plant to a top capacity of 100 tons a day of roofing asphalt and special grades of air-blown asphalt. Two stills for the manufacture of air-blown asphalt will be erected adjoining existing steam-blown asphalt facilities.

The new installation will receive raw materials from existing units at the company's Edmonds and Oleum, Calif., refineries. Estimated cost of the two new stills and related pumps, blowers, tanks,

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Who's Building . . .

instrumentation, piping and a large warehouse reaches some $400,000. The project is due to raise the company's investment in its facilities at Edmonds to about $1.5 million.

Completion is scheduled for early 1956. The new installation will produce and package all normal requirements of air-blown asphalt in Washington, Idaho, British Columbia and Alaska, an area which now imports all its needs from California and Oregon.

Imperial Oil, Ltd., planning to spend more than $5 million in improving equipment at its Sarina, Ont., refinery, has awarded the contract for construction of a 13,500-barrel-a-day catalytic-reforming unit. The new installation, due for completion in September 1956, will be built by The Fluor Corporation of Canada, Ltd. Process designs will be supplied by Imperial engineers, with Fluor handling mechanical design.

Southwestern Oil and Refining Company, planning to add a catalytic reformer to its refining facilities at Corpus Christi, Texas, has selected The Refinery Engineering Company to handle design and construction for the 9000-barrel-a-day unit. The new reformer will go on stream early in 1956.

The Standard Oil Company (Ohio) plans to add an $800,000 dry-ice plant to its $17-million petrochemical facilities under construction at Lima, Ohio. The new carbon-dioxide unit will have a 75-ton-a-day capacity. It is due to go into production by May 1956.

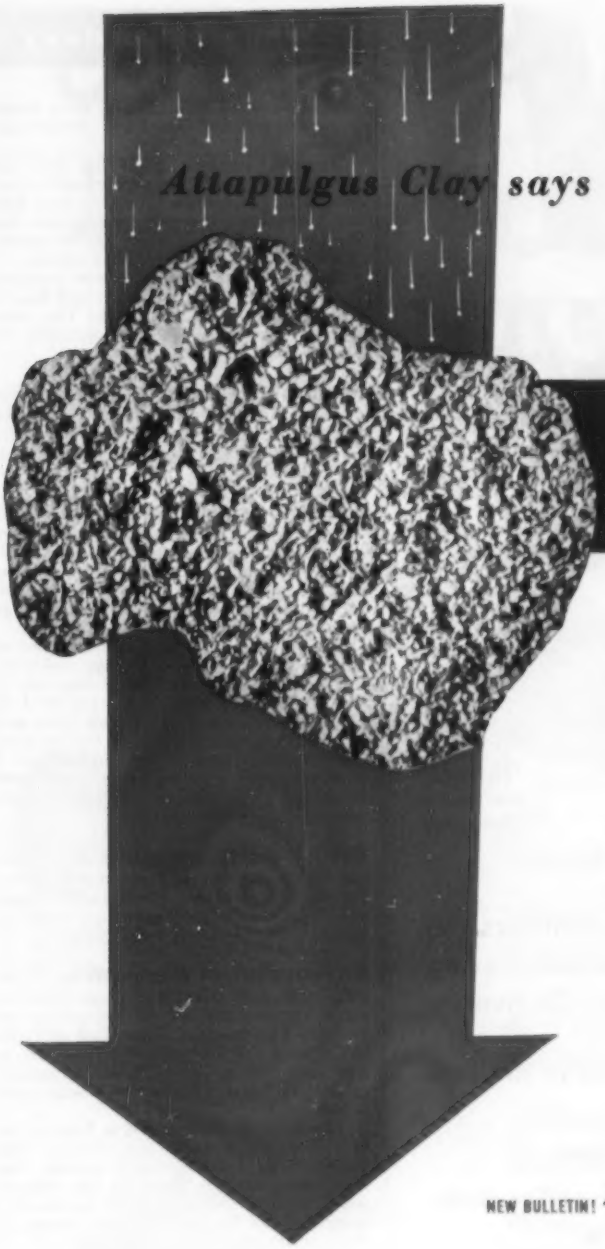
Construction work on the Sohio petrochemical plant is ahead of schedule, with the 300-ton-a-day anhydrous-ammonia unit expected to be put in operation in October, and the 180-ton-a-day nitric-acid plant scheduled to start operations in November. The urea unit will be placed in operation early in 1956.

National Co-Operative Refinery Association will add a 1400-barrel-a-day alkylation unit to its refinery at McPherson, Kan., bringing to nearly $10 million the value of improvements and additions made at the refinery in the past six years.

Italian Government is considering a Romanian proposal to set up a joint Italian-Romanian company to build a refinery near Rome. The new installation would be built for a 20,000-barrel-a-day capacity.

Antar Petroles de l'Atlantique will install a 10,800-barrel-a-day catalytic reformer at its refinery in Donges, France. The new facility, a Houdriformer, will process naphthas from Iraq crude, and a blocked operation will permit the alternate production of high-octane gasoline and aromatics. Houdry Process Corporation will furnish process design, with engineering and construction to be handled by Hydrocarbon Research, Inc.

North Star Oil Company, after much field work, will begin moving its refinery more than 2000 miles from St. Boniface, Man., to Grand Prairie in northwest Alberta. The refinery will be modern-



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ized at a cost of $2 million to serve northwest Alberta and northeast British Columbia.

The St. Boniface plant has been replaced by a larger refinery recently completed for the company by Canadian Kellog Company. The new installation was built for a daily capacity of 12,000 barrels. It cost the company some $10 million.

Brought up to date at its new location, the former St. Boniface plant will have a daily capacity of 2500 barrels. The refinery is expected to go into operation by March 1956.

Thompson Chemical Company has awarded an engineering and design contract to Scientific Design Company, Inc., for a polyvinyl-chloride plant to be built at New Dighton, Miss.

Midland Cooperatives, Inc., will install a 3000-barrel-a-day catalytic reformer at Cushing, Okla., as part of a $750,000 program to increase the refinery's output of high-octane gasoline. The unit, a Platformer to be built by Procon, Inc., will go on stream in April, 1956.

The project also includes construction of 120,000 more barrels of storage and addition of a new de-salting unit. Capacity of the Cushing refinery was increased to 12,000 barrels a day about two years ago.

The Platformer is designed by Universal Oil Products Company for addition of a Rexformer or a similar facility if still more yields of high-octane are required. The new reformer will cost $600,000.

Shell Italiana Company has been granted permission to build a refinery at Palermo. The Sicilian government cleared the Royal Dutch/Shell group for construction of a 20,000-barrel-a-day plant.

Government of Saurashtra, an Indian state, has completed plans with various interests for an oil refinery to be built at Bhavnagar, on the Gulf of Cambay. Plans for the refinery, expected to cost some $31,500,000, call for a capacity to process 1.5 million tons of Irania crude a year.

The Iranian government is believed to be willing to invest in the venture. Two businessmen, believed to represent the Aga Khan, also are financing the refinery which will be the first to be financially-controlled by Indians and the fourth in the country.

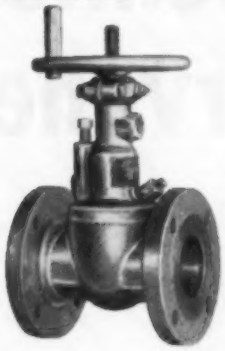
Under Construction—

Canadian Oil Companies, Ltd., has let the contract for a $300,000 administration building and plant-protection building at its Sarnia, Ont., refinery. The new structures will be erected by Con-Eng Contractors, a London, Ont., firm. Plans call for a two-story administration building and a two story plant protection building.

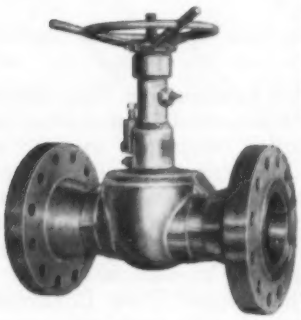
Tide Water Associated Oil Company is installing the world's largest fluid coking unit at its refinery in Avon, Calif. With a daily capacity of 42,000 barrels, the new facility will be 11 times as large as the only unit of its kind in operation.

The coking plant, due for completion in May, 1956, is being built by Bechtel Corporation. It will upgrade heavy fuel oils

ORBIT VALVES HOLD



Full Round Opening Flanged End, Sizes: 1", 1½", 2", 2½", 3", 4".



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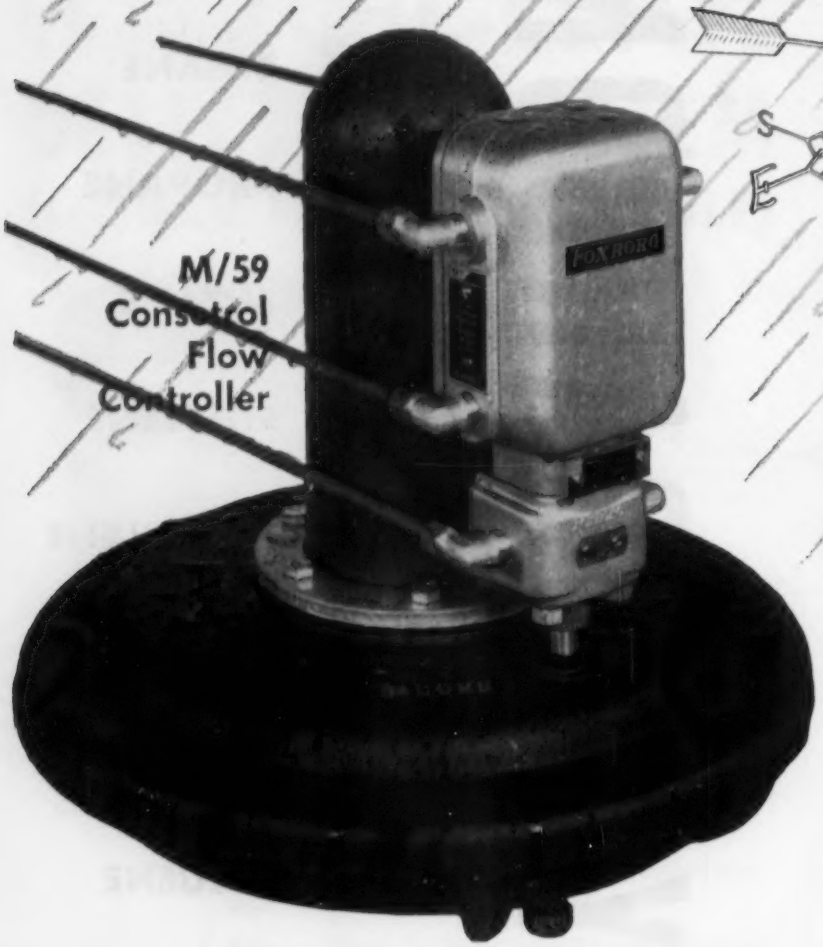
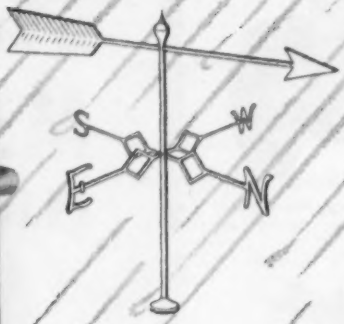


M/59 Consotrol Flow Controller



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into components of gasoline and heating oils, and in the process, produce granulated coke for use in metallurgy and as a fuel.

The first commercial fluid coker ever built was completed earlier this year by The Carter Oil Company at its refinery in Billings, Mont. The Carter unit was built for a daily capacity of 3800 barrels of fresh feed.

Getting underway at Avon before the end of 1955 will be construction of a hydrodesulfurization unit to remove sulphur and nitrogen impurities from gasoline raw materials. The facility will be built for 24,000 barrels a day.

Also scheduled as part of the company's current expansion is construction of a new gas-recovery plant, enlargement of the refinery's Fluid catalytic-cracking equipment and erection of allitional service buildings.

All these facilities are scheduled for completion next spring and will increase the refinery's output by 30 percent. Cost of the improvements were not available, but previous estimates have run to $20 million.

Gonzales Chemical Industries, Inc., will begin construction on a new anhydrous-ammonia, sulfuric-acid and ammonium-sulfate plant at Guanica, Puerto Rico. To be the country's first ammonia-products plant, the new installation will be built by The Lummus Company, which also is handling the design and engineering.

Output is expected to run 42,000 tons of anhydrous ammonia a year. Part of the product will be sold as such, and the balance will be converted to aqueous ammonia, sulfuric acid, ammonium sulfate and possibly other materials.

Standard Oil Company of California is entering the final phase of construction work on the $7-million isophthalic plant being built at its Richmond, Calif., refinery. The new installation, designed to turn out 50 million pounds of the material a year, is being made by The H. K. Ferguson Company. The plant will be started up late this year.

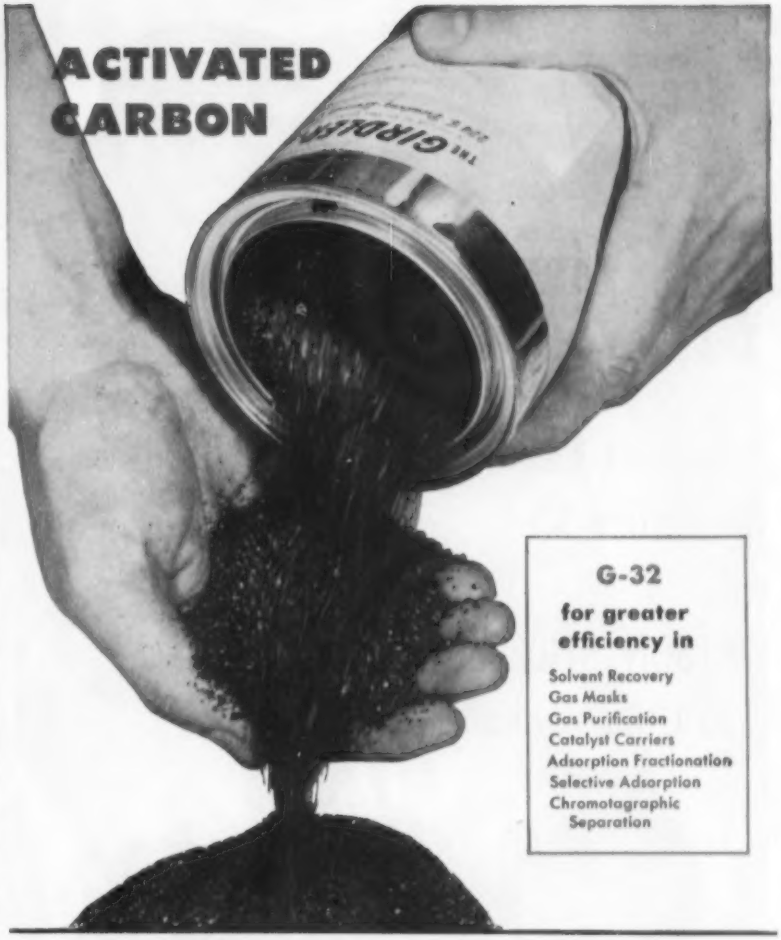
American Oil Company is breaking ground for its $80-million refinery, to be built at Yorktown, Va. The refinery, designed for a daily capacity of 30,000 barrels, will be constructed by The M. W. Kellogg Company.

Kellogg is building the plant's combination distillation and catalytic-cracking plant with its integral polymerization and attendant treating facilities. The Lummus Company will build a petroleum coking unit with a capacity for more than 500 tons a day.

Five major contracts already have been awarded with two other contracts to be let this year. Work still to be contracted is for a two-story office building and for two process units, a 7600-barrel-a-day Ultraformer and an 18,000-barrel-a-day desulphurization unit.

Already under construction is a $1,750,000 pier to accommodate tankers and barges on the York River. Also, Chicago Bridge and Iron Company has started preliminary work on construction of 63 steel tanks with a total capacity of more than 3,770,000 barrels.

When the refinery goes on stream in 1957, it will produce more than 1,100,000



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gallons of gasoline a day. It also will produce kerosine, heating oil, liquefied petroleum gas and coke. Construction is expected to be completed late in 1956.

Seminole Oil Company, formed by Frontier Refining Company and other interests to operate a new refinery at Fort Pierce, Fla., is due to start construction of the $16-million project. The plant, to be built for a daily capacity of 15,000 barrels, will be on stream by late 1956.

Shell Oil Company has the major process equipment in place at its 50,000-barrel-a-day refinery under construction at Anacortes, Wash. Plant facilities include crude distillation, catalytic reforming, gas recovery and catalytic polymerization. The refinery, being built by Bechtel Corporation, is due to go on stream early in 1956. The new installation is expected to cost $75 million.

Deutsche Shell, A. G., plans to increase capacity of its 14,000-barrel-a-day Hamburg, West Germany, refinery to 52,000 barrels. New installations will include a catalytic cracking unit, a hydrodesulfurization unit and a second Platformer. The plant's first Platformer, now under construction, will have a daily capacity of 2000 barrels.

Completed—

Husky Oil Company has completed a $1-million expansion of its refinery in Fort William, Ont. The project saw an increase in the plant's capacity from 1800 barrels a day to 5000 barrels and the addition of Platforming equipment.

Texas Gas Corporation has put on stream a 2500-barrel-a-day Platformer at its Winnie, Texas, plant. Equipment from an existing catalytic reformer was used in the construction of the new unit, now being used to upgrade a naphtha cut derived from the company's processing plants. The reformate will be used as a blending stock. Universal Oil Products Company engineered, designed and licensed the unit. Procon, Inc., was the contractor.

Empire Oil Company has placed on stream a natural gasoline plant near Odessa, Texas. The plant was built with an initial processing capacity of 4 Mmcf a day. Facilities were sized to permit expansion to 10 Mmcf. Built at an estimated cost of $250,000, the new installation will turn out 2000 gallons a day of liquid products.

Sun Oil Company, which recently placed on stream a 27,000-barrel-a-day Houdriflow catalytic-cracking plant at its refinery in Marcus Hook, Pa., now has completed an 18,000-barrel-a-day Houdriformer at the Marcus Hook refinery. The new catalytic reformer, built at a cost of $5 million, is already in operation.

Hydrogen from the new reformer will be used in the manufacture of anhydrous ammonia at a new $9-million plant under construction at the Sun refinery. The ammonia plant, scheduled for completion early in 1956, is being built by Catalytic Construction Company, which also handled

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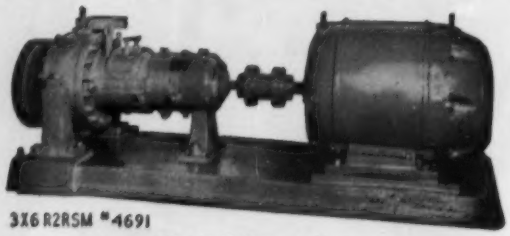
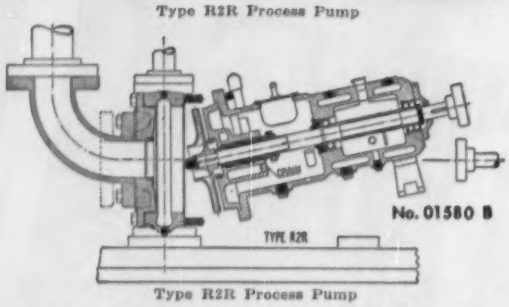


Type R2R Process Pump



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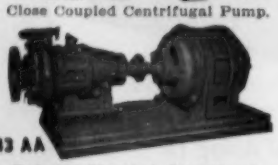
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids.



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construction on the Houdriflow and Houdriformer units.

The catalytic-cracking unit is one of the world's two largest Houdriflow plants. The other recently was completed at Sun's Toledo, Ohio, refinery. (**Petroleum REFINER, July 1955, page 183.**)

Mississippi River Chemical Company is nearing completion of its 200-ton-a-day anhydrous-ammonia plant at Selma, Mo. Equipment for the new facility, being built at a cost of $15.8 million, was licensed by Texaco Development Corporation. The Fluor Corporation, Ltd., handled by construction and engineering.

Brin Chemical Corporation has gone on stream with a new acid-oils plant in Tulsa. The plant, costing more than $100,000 will produce phenols, cresols, and xylenols. Raw material will come from a caustic-treating stream at the nearby The Texas Company refinery.

Consolidated Chemical Industries has placed on stream two sludge acid regeneration plants costing some $8 million. The plants, at Houston and Baytown, Texas, were designed and constructed by Chemical Construction Corporation. Together, the new installations have the capacity to produce 280,000 tons a year of regenerated sulfuric acid.

Esso Standard Oil Company has placed on stream the second and largest fluid coking unit in the U. S. Bechtel Corporation, which will build a fluid coker for Tide Water Associated Oil Company at Avon, Calif., installed the 10,000-barrel-a-day Esso unit at the company's Baltimore refinery.

The company also placed on stream two new pipe stills, new Hydroforming and Hydrofining facilities and revamped the fluid catalytic-cracking equipment at Baltimore. Both the Hydrofiner and Hydroformer were installed by Foster Wheeler Corporation.

Petroles Mexicanos has completed its 50,000-barrel-a-day expansion of facilities at the Atzcapotzalco refinery, near Mexico City. Engineering for the $12-million project was handled by Arthur G. McKee Company, and Pemex personnel did the construction.

New process equipment, which raised the plant's daily capacity to 100,000 barrels, includes a 50,000-barrel-a-day primary distillation unit, a 32,000-barrel-a-day vacuum unit, a 22,000-barrel-a-day catalytic cracker, a 12,000-barrel-a-day desulfurization unit, a polymerization unit and additional facilities which give the refinery 2300 barrels a day of alkylation capacity.

McColl-Frontenac Oil Company, Ltd., has gone on stream with the first combination Platforming-Unifining unit to be placed in operation outside the U. S. The new unit, designed for a daily capacity of 11,970 barrels, was completed at the company's refinery in Montreal, Queb.

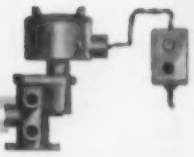
The installation was made as part of a $4-million improvement program for refineries at Montreal and Edmonton, Alba. At Edmonton, the company increased the

For more data on advertised products, use Readers' Service Cards, last page.

For Remote Shut-off Applications...

ANNIN CYLINDER VALVES

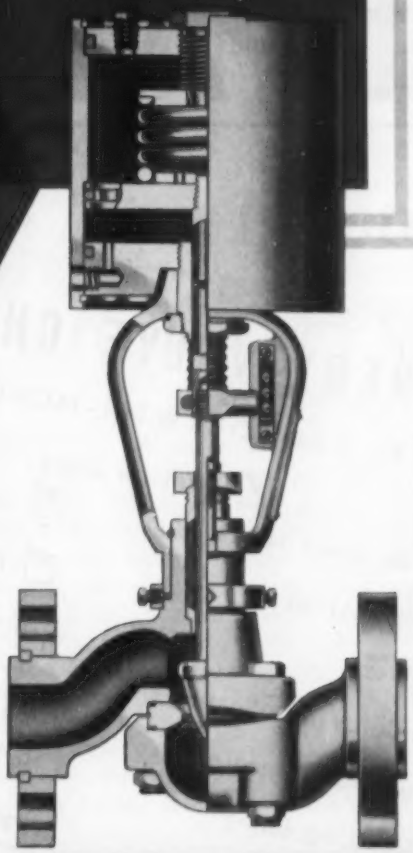
provide the complete answer!



ELECTRO-PNEUMATIC SOLENOID PILOT ACTUATED

3-WAY OR 4-WAY MANUAL AIR ACTUATED

PNEUMATIC CONTROLLER ACTUATED



MODEL 4520

MODEL 6520

...with these advantages:

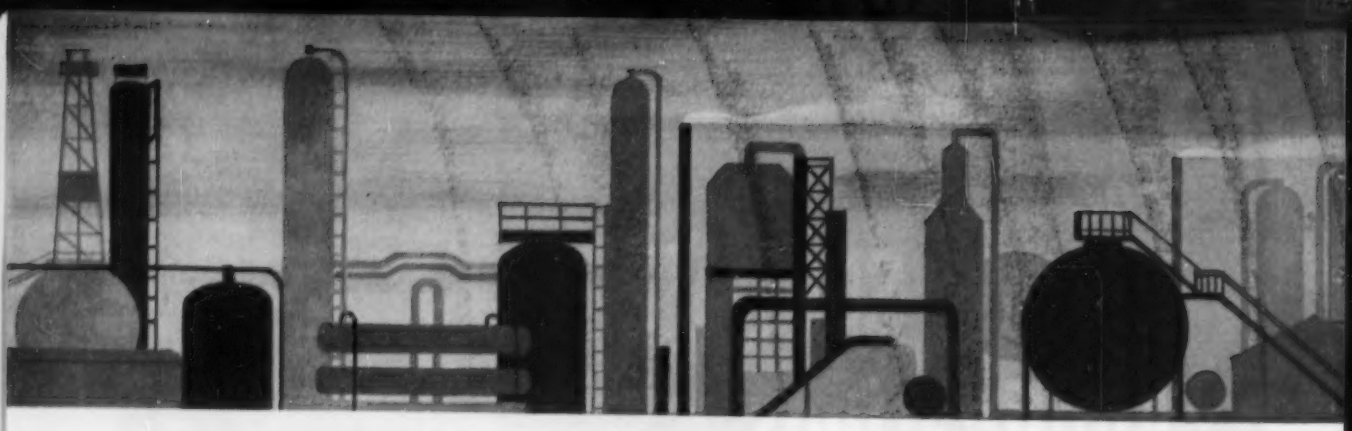
- Positive shut-off
- Fast action
- Spring to open
  or
- Spring to close
- Globe, angle & 3-way bodies
- Carbon steel and all cast and forged alloys available
- Metal seats for high temperatures

and absolute shut-off dependability and safety with **ANNICO TEFSEAL SEATS** proven in dangerous services, such as Liquid Oxygen, Fuming Nitric Acid, Liquid Nitrogen and CO_2, Fuels and other FLUIDS at all pressures and temperatures —300° to +450° F

ANNIN *Control* VALVES

THE ANNIN COMPANY
6570 EAST TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA

For more data on advertised products, use Readers' Service Cards, last page.

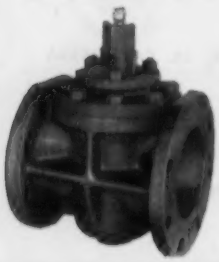


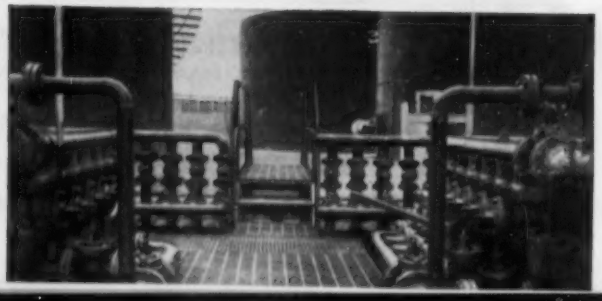
Where It PAYS To Use

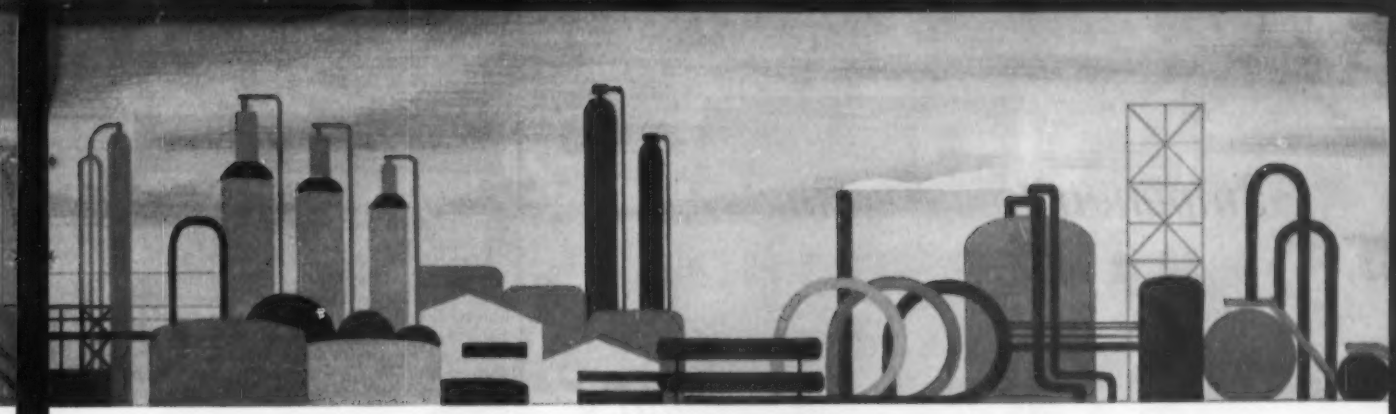
REFINERY VALVE CHECK LIST

Where To Use ROCKWELL-NORDSTROM Valves

- ☑ Transfer Lines
- ☑ Crude Lines To Refinery
- ☑ Heater Lines
- ☑ Towers
- ☑ Relief Valve Settings
- ☑ Lube Oil Treating
- ☑ Blending Lines
- ☑ Dewaxing
- ☑ Filtering
- ☑ Solvent Extraction
- ☑ Products Lines
- ☑ Tank Farms
- ☑ Loading Racks
- ☑ Fuel and Supply Lines
- ☑ Cat Crackers
- ☑ Platforming Units







Rockwell-Nordstrom Valves

For The Most Economical, Trouble-Free Refinery Valve Service

Look very carefully at the refinery valve check list on the left. If you are not now using Rockwell-Nordstrom valves at these important points, you have a real opportunity to make worth-while savings through longer, more trouble-free valve life, and lower repair, replacement and down time costs. Here are the reasons:

ECONOMICAL: Rockwell-Nordstrom valves are the most economical refinery valves you can use. Pressurized lubrication—which forms the time-proven leakproof seal—also eliminates metal-to-metal friction and "armor plates" the working parts against corrosive or erosive line material. And the valve seats, the parts that are "eaten out" fastest on ordinary valves, are *never* exposed to line material.

Rockwell-Nordstrom valves will start saving money for you the day they go on-stream because lubrication and rugged design eliminate costly repair and replacement and assure longer economic valve life.

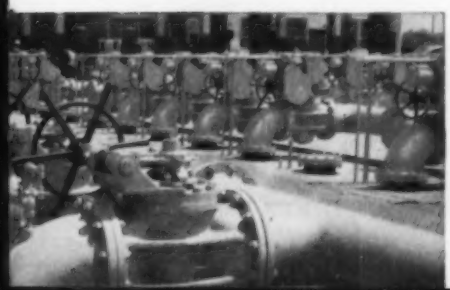
TROUBLE-FREE: Refinery engineers have been standardizing on Rockwell-Nordstrom valves for forty years. They've learned that the pressurized lubricant seal and positive shut-off assure *safe*, leakproof operation in *any* refinery service. Refinery operations men prefer Rockwell-Nordstrom valves because quarter turn closure permits accurate, smooth flow control. There are no bulky, large open cavities on Rockwell-Nordstrom valves; they require less space in manifolds. "Open-Close" guess work is eliminated—a glance at the wrench instantly tells plug position.

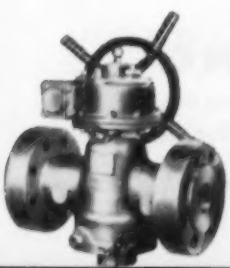
Rockwell-Nordstrom valves are available in *the only complete range* of lubricated plug valve sizes and pressure-temperature ratings in steel, semi-steel and corrosion resisting alloy patterns. Write for complete information today: Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Limited

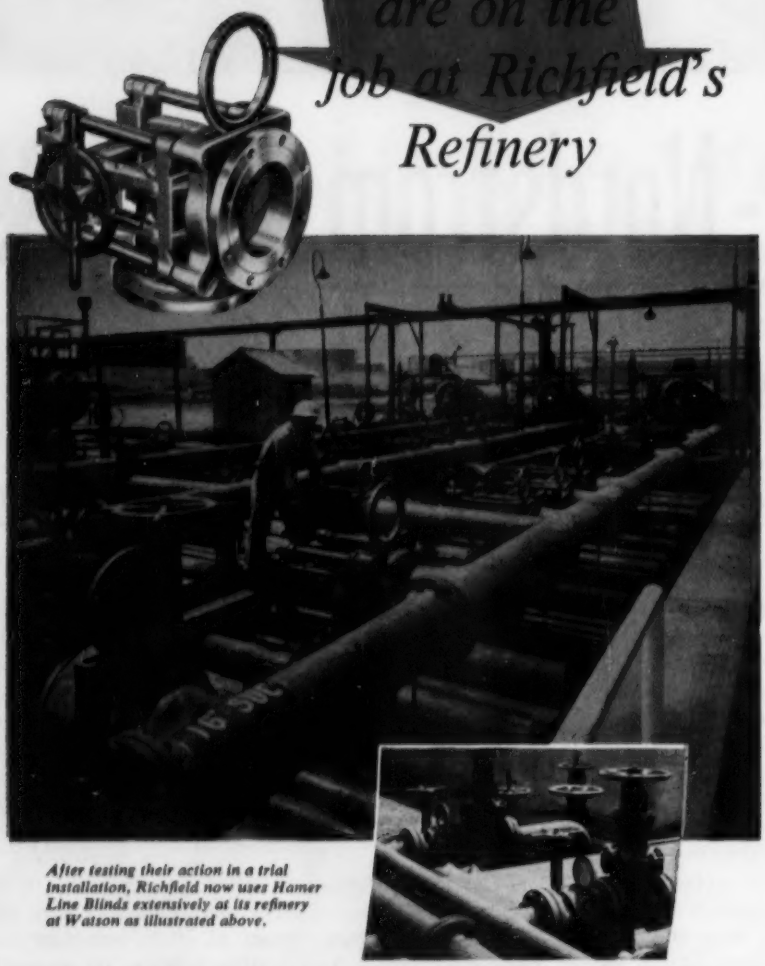
ROCKWELL-Nordstrom VALVES

LUBRICANT SEALED FOR POSITIVE SHUT-OFF





Impenetrable Sealing
HAMER BLINDS
are on the job at Richfield's Refinery



After testing their action in a trial installation, Richfield now uses Hamer Line Blinds extensively at its refinery at Watson as illustrated above.

HAMER *Visible Shut-off* LINE BLIND VALVES

HAMER *Plug Valves*

Thousands of users have proven the easy and immediate operation of Hamer Plug Valves. Will not stick or freeze.

Refinery operations require a valve that will provide a continual leakproof line shutoff. Hamer Blinds with their foolproof sealing action are unsurpassed for providing an absolute line seal that's both positive and permanent. In addition, Hamer Blinds fast, one minute, one man operation literally pay for their cost in downtime saving.

Send for FREE Catalog

HAMER VALVES, INC.
2919 Gardenia Ave., Long Beach 6, Calif.
Representatives throughout the World

Who's Building . . .

plant's crude capacity to 11,000 barrels a day and built a 3000-barrel-a-day thermal cracking unit.

The Unifining unit at Montreal is serving as a feed preparation section for the reformer, and using excess hydrogen from the reforming operation to process straight-run naphthas derived from Arabian or a mixture of Venezuelan crudes. The Platformer is producing a 99 plus leaded-octane reformate for blending to make premium gasolines.

The combination unit at Montreal was built by Procon (Canada), Ltd., and Edmonton cracking unit was erected by Canadian Kellogg Company.

Hancock Oil Company has completed a $5-million refinery expansion program to step up both quality and quantity of gasolines produced at its Long Beach, Calif., refinery.

The company has placed on stream a new TCC unit, with a 6000-barrel-a-day fresh-feed capacity; a 500-barrel-a-day UOP catalytic polymerization unit, together with feed preparation, gasoline recovery and sulphur-recovery units.

Ralph M. Parsons Company held contracts covering engineering, procurement and construction, which included installation of product handling and transfer facilities.

The Pure Oil Company, with 15 other firms and individuals, has started operations at a new $3-million gasoline plant in Morgan County, Colo. The plant was built to process 20 Mmcf. of gas a day. Construction was handled by Stearns-Rogers Manufacturing Company.

The Texas Company has completed installation of a new combination Platforming-Unifining unit at its refinery in West Tulsa, Okla., bringing to seven the number of such facilities built for Texaco refineries. Two others are in various stages of construction.

The new combination unit at Tulsa has a capacity of 9000 barrels a day. Mid-Continent-type crudes are charged to the Unifiner in preparation of feed stock for the reforming equipment. The Platformer is designed to produce a 90 F-1 clear-octane blending compound.

At another Texaco refinery—in Wilmington, Calif.—a 10,000-barrel-a-day Platformer has gone into operation. Also producing 90 F-1 clear reformate, the Wilmington unit is processing naphthas derived from mixed California crudes.

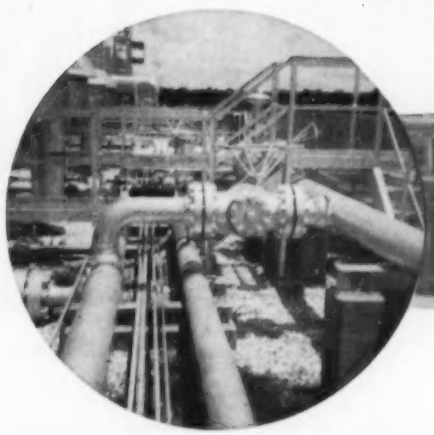
By the last of 1955 ten reforming units will be in operation or under construction at Texaco refineries. The ten units will represent a combined daily capacity to produce 117,000 barrels of reformate.

The company recently completed a 1000-barrel-a-day isomerization unit at Wilmington and now is installing a 25,000-barrel-a-day furfural unit. The refinery's new reforming and hydrotreating facilities were erected by C. F. Braun & Company.

Standard Oil Company of Texas has completed a 4300-barrel-a-day catalytic reformer at its refinery in El Paso, Texas. The unit, a Platformer, is processing heavy gasoline fractions derived from West Texas crudes.

Universal Oil Products Company licensed the unit, and it was installed by Bechtel Corporation which also handle engineering. The project was to have cost $2.7 million.

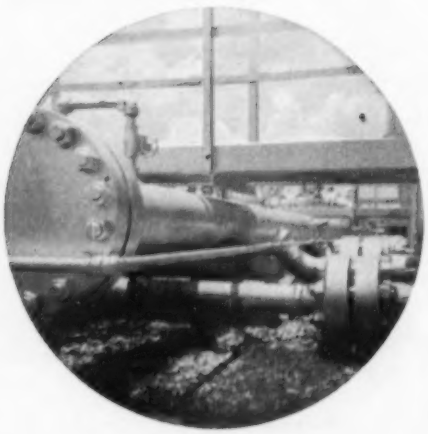
4500 psi Recycling Plant



$ 18,000 SAVED

on branch connections alone!

By requesting the alternate use of Weldolet Welding Fittings in all weights and sizes the piping contractor was able to lower his bid sufficiently to be awarded the job!



This recently completed recycling plant in Louisiana was designed and engineered in full accordance with the ASA and ASME Codes and operates at a maximum pressure of 4500 psi and 225°.

The piping engineers on this job were confronted with a number of tough problems. The plant was to be operated at extremely high pressures. The terrain was swampy which meant the fittings had to withstand the additional stresses exerted by a settling foundation. The piping also had to stand up under rugged vibration conditions. The many design features of Weldolet Welding Fittings in both full size and reducing size outlets provided the safe, practical and most economical answer to these knotty service problems.

WELDING FITTINGS DIVISION

BONNEY FORGE & TOOL WORKS

721 MEADOW STREET, ALLENTOWN, PENNA.

For more data on advertised products, use Readers' Service Cards, last page.

Developing Technical Personnel Through Performance Evaluation

Professional people are eager to know "where they stand" with management Here is a merit rating plan that will improve morale and measure promotability.

Rex E. Gilbreath, Phillips Petroleum Company, Bartlesville, Okla.

ARE YOU SATISFIED with your method of developing technical personnel? Would you like to improve the relationship between these employes and their supervisors?

The answer to your problem may lie in performance evaluation, a dressed-up name for merit rating or performance rating.

Performance evaluation has proven workable in the Research and Development Department of Phillips Petroleum Company at Bartlesville, which has a personnel of about 850, of whom approximately 475 are classed as professional or supervisory. Their fields include chemistry, physics, law, mathematics and engineering.

Generally, Phillips felt that anything that could be done to increase understanding among its professional people would be beneficial. Specifically, there were these reasons for installing a performance evaluation program:

- The department had grown so fast that there was no first-hand knowledge of people at the lower levels.
- The Employe Relations Section wanted a means of aiding supervisors to assess their employes in a formal and analytical manner.
- There was a desire to install a counseling program, but it was felt that performance evaluation should precede counseling. The Employe Relations Section believed that the two programs would give professional people an opportunity to know "how they were doing" and would consequently enhance employe morale.

(In a survey conducted by the National Society of Professional Engineers as to why professional people were joining unions, more than 50 percent of the replies indicated unhappiness because "we don't know where we stand.")

Many other plans were reviewed to determine what type of program was

PERSONAL & CONFIDENTIAL

RESEARCH AND DEVELOPMENT DEPARTMENT
(Phillips Petroleum Co.)

PERFORMANCE EVALUATION
(Professional and Supervisory)

Name: _____ Division: _____ Empl. Date: _____

Position: _____ Branch: _____ Division Time: _____

Date and Type Degrees:
B.S. _____ Section: _____ Review Date: _____
M.S. _____
Ph.D. _____ Supervisor: _____
Other _____

Brief description of current job duties: (In your own words, state what he is currently doing.)

HOW IS THIS EMPLOYEE'S PERFORMANCE ON HIS PRESENT JOB?
(Check the box which you feel best describes his performance.)

Outstanding ☐	Superior, above average but not outstanding. ☐	Good, neither superior nor inferior. ☐	Fair ☐	Inadequate ☐

I. RESULTS AND ACCOMPLISHMENTS

Write a brief statement describing his performance since the last evaluation or during the past six months. Indicate strong and weak points.

II. EMPLOYEE'S STATUS

Indicate by checking the proper box which of the following most closely describes the employee's situation. The promotability status may be based on either technical ability, supervisory ability or a combination of both. Check whether technical, supervisory or both. Use the space provided below for your remarks and recommendations.

☐ 1. **Immediately Promotable:** Individual can immediately fill positions at a higher responsibility level. Check the area, describe position and give reasons:
Technical _____
Supervisory _____

☐ 2. **Promotable:** The individual can fill a job at a higher responsibility level with further training. Check the area, and estimate time necessary:
Technical _____
Supervisory _____

☐ 3. **Satisfactory:** This individual is doing what is expected on his present job, (he may be a very valuable employee) but advancement beyond his present position is not presently indicated. If transfer to another field would improve advancement possibilities, indicate the field.

☐ 4. **Less Than Satisfactory:** The individual's performance is not acceptable in his present position. State nature of principal deficiencies. Indicate whether performance improvement with help is probable. If not, should he be transferred, demoted, or dismissed?

REMARKS:

III. OTHER PERSONAL QUALIFICATIONS

Indicate any characteristics which have not already been mentioned that might fit him for higher responsibilities. Indicate any technical or administrative ability which this employee has which is not currently being used. These qualifications or characteristics may come from either past education or experience.

Pages 1 and 2, condensed, of Evaluation Chart

HAUNTED by departed PEP from your motor fuel?

BLENDING WARREN NATURAL GASOLINE WITH YOUR PRESENT HIGH QUALITY MOTOR FUEL WILL GIVE IT . . .

RETAINED VOLATILITY

(in every season)

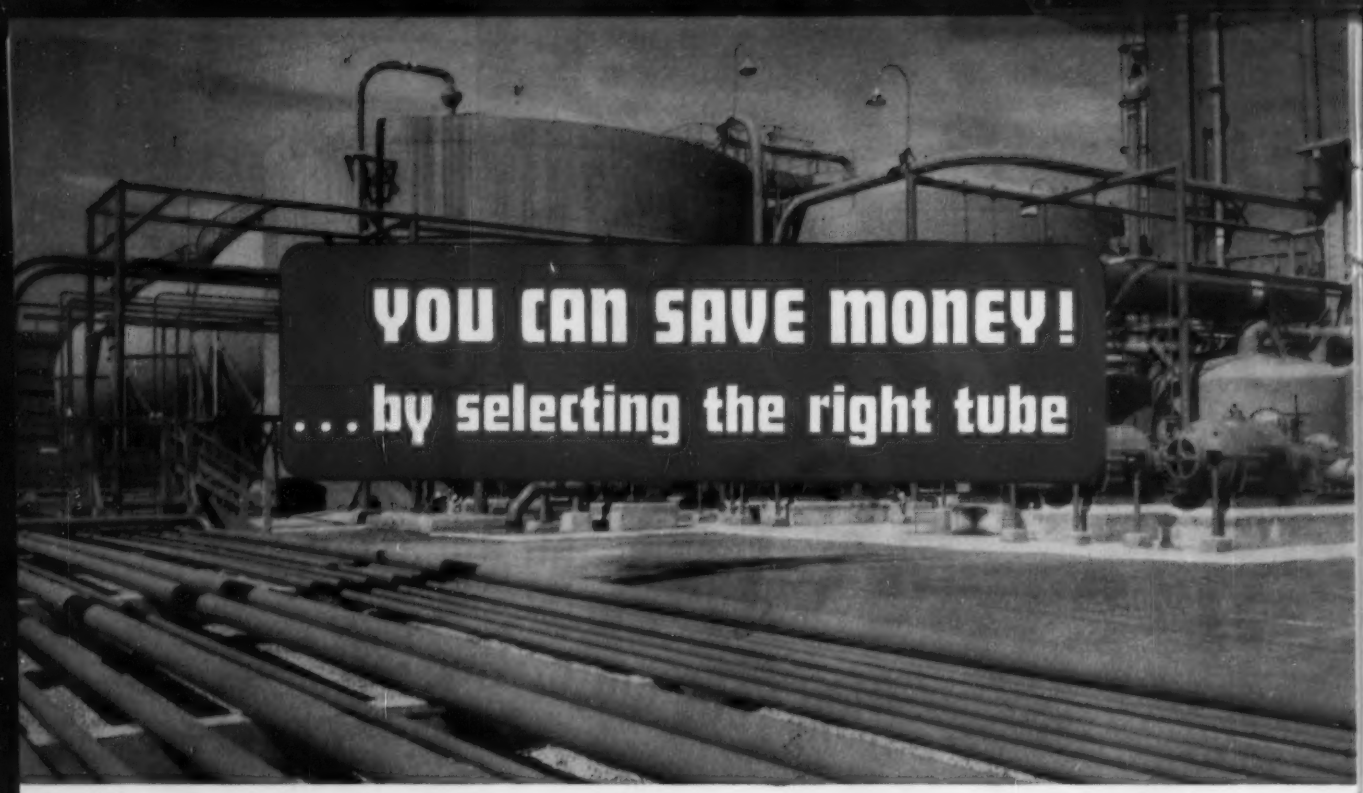
You can depend on WARREN'S production, transportation, storage and service for the grade and quantity of NATURAL GASOLINE you want — where and when you want it.

WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA • Cable Addresses: STAVOLENE, WARREN

EXPORT TERMINALS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, HOUSTON, TEXAS, SAN PEDRO, CALIF.



YOU CAN SAVE MONEY!
. . . by selecting the right tube

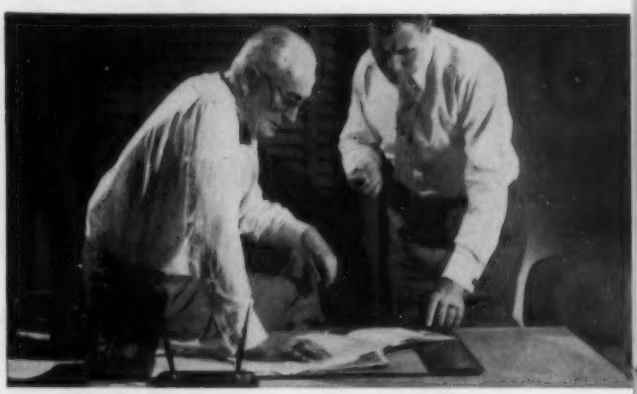
● The selection of refinery pipe and tubes presents many problems; basic differences in equipment, variations in fabricating operations, service pressure, high or low temperature conditions, presence of corrosive media, etc. Each of these factors must be considered in determining which pipe or tubing material is just right for a particular installation. Therefore, to insure you the best material at the lowest cost, the selection should be made by a tubing specialist.

Through research and laboratory experimentation, through on-the-scene observations, and by studying actual installations, National Tube refinery specialists have built up a collection of case histories that date back through 60 years of solving all types of tubing problems. The result of this extensive experience is the list of 25 different steel tube analyses shown here. Each analysis has been designed to combat specific refinery conditions, and each one has been tested and retested in actual refinery service. Other chemical compositions are also available in tubular products, and a wide variety of high temperature problems are now under study.

Examine the list of analyses. Then, before you make a decision as to which one you'll use, get in touch with us. Our engineers will help you select the analysis that will give you utmost efficiency coupled with the most economical performance. Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

NATIONAL TUBE'S 25 DIFFERENT STEEL TUBE ANALYSES:

Carbon	2¼ Cr, 1 Mo	8 Cr, ½ Mo	18-8
Carbon, ½ Mo	2½ Cr, ½ Mo, ¾ Si	8 Cr, 1 Mo	18-8 Ti
½ Cr, ½ Mo	3 Cr, 1 Mo	9 Cr, 1 Mo	18-8 Cb
1 Cr, ½ Mo	5 Cr, ½ Mo	12 Cr	18-8 Mo
1¼ Cr, ½ Mo	5 Cr, ½ Mo, 1½ Si	12 Cr, Al	25-20
2 Cr, ½ Mo	7 Cr, ½ Mo	17 Cr	3½ Ni
		5 Ni	



NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

NATIONAL SEAMLESS PIPE AND TUBES

SEAMLESS WITHOUT WELDS

UNITED STATES STEEL

As Management Sees It . . .

most desirable. It was learned that:

- Some assigned numbers to their employes without being sure what the numbers meant.
- Some ranked employes from first to last without knowing quite why.
- Some devised elaborate forms which were filled out, filed and forgotten.
- Some linked merit rating and salary administration to the detriment of a true conception of an employe's real merit. It was also found that many supervisors distrusted merit rating in general.
- Some adopted a forced choice system which too often left the supervisor in the dark concerning results.

From these findings came the rough outlines of a program with these objectives:

- Information on how employes were performing, what they could do to improve, and what their possibilities were.
- An evaluation placing as little

IV. DEVELOPMENT OF INDIVIDUAL

(Thinking in terms of development, evaluate the individual in each of the following traits. Each trait should be evaluated by the three point scale below. In the event a statement does not apply, leave blank.)

(A) More than adequate for present job.	(B) Adequate for present job.	(C) Below standards for present job.

1. Technical Knowledge
   a. Present assignment
   b. Broad knowledge of field
   c. Education
   d. Experience
   e. Ability to apply knowledge
   f. Improving himself
2. Job Performance
   a. Quality of work
   b. Quantity of work
   c. Thinking creatively
   d. Working independently
   e. Planning work
   f. Making decisions
   g. Appraising and developing others
   h. Working safely
3. Communication Ability
   a. With superiors
   b. With subordinates
   c. With persons on same level
   d. With other groups and divisions
   e. In oral expression
   f. In written expression
   g. In leading a conference or discussion
4. Personal Characteristics
   a. Ability to get along with others
   b. Company loyalty
   c. Attitude toward present job
   d. Attendance record
   e. Personal appearance

V. TRAINING RECOMMENDED

With the knowledge that "The Company can develop only with its people," what specific measures should be taken to further develop this employee?

NEED DEFINED

RECOMMENDATIONS

(This section will be filled in by Employee Relations Section)

Date Training Started _____ Date Training Completed _____

Results:

Evaluation prepared by _____ Date _____

Reviewed by _____ Date _____

Comments:

WARNING: Be sure necessary approvals have been obtained before discussion with employee.

— DISCUSSION WITH EMPLOYEE —

Every employee desires to know WHERE HE STANDS. The information compiled on the previous pages can be used as a guide in discussing his progress with him.

A record of this "progress interview" should be compiled by answering as many of the following questions as possible after completion of Interview:

CAUTION: Let employee do most of talking—Do Not Discuss Salary Changes—Do Not Ask Direct Questions: Report Results of Evaluation just before termination of interview.

1. Does employee seem satisfied with progress to date?
2. What does this employee believe to be his most outstanding abilities?
3. What abilities does employee recognize as needing improvement?
4. Does employee like present work and position?
5. If he is dissatisfied with present position, does he desire a transfer to another type of work, department, or location . . . Explain:
6. Does he indicate any strong preference for straight technical work or administrative work?
7. What is he doing to improve himself?
8. Has he any hobbies or outside interests of occupational significance?

Signature of Immediate Supervisor _____ Date Completed _____

Pages 3 and 4, condensed, of Evaluation Chart

now...

more effective and economical

ENTRAINMENT SEPARATION

with the

NEW HI-THRUPUT HERRINGBONED MIST ELIMINATOR

Check these important points:

1. Half the pressure drop of Standard Mist Eliminator.
2. Safe operating limits – 10% to 12% higher velocity.
3. Entrainment removal practically 100% over wider operating range.
4. Three to four times longer on-stream life under coking conditions or where solids are present.
5. Lower cost – wires repositioned by Herringbone Fold*.

*U.S. Patent No. 2,565,846, Aug. 28, 1951

These photos show the difference. Full explanation given in our Booklet ME-5.

Send for Revealing Booklet ME-5. Learn how repositioning wires by patented Herringbone process and change in size and contour of mesh openings make this new Mist Eliminator more effective and economical.

METAL TEXTILE CORPORATION

Roselle, New Jersey

Metal Textile Corporation of Canada, Ltd., Hamilton, Ont.

Here's how

on low-capacity

- **Bulletin 755:**
  "AiROYmetric Pressure Generators."
  Describes use of automatic pressure generators in metal fabrication, hydrostatic testing, and high pressure synthesis.

- **Bulletin 555:**
  "Super-Pressure Pumps."
  Describes new line of controlled volume pumps for pressures up to 50,000 psi.

- **Bulletin H20-1:**
  "Milton Roy H-20 Pumps."
  For accurate, dependable, low-cost chemical feed—in water treating, processing, additive metering, and "packaged" systems.

- **Bulletin 953:**
  "Controlled Volume Pumps for Water Treating Systems."
  Prepared with assistance of leading water treating authorities. Principal emphasis on water conditioning for industrial use.

- **Bulletin 455:**
  "Controlled Volume Pumps in Paper Making."
  Describes and illustrates more than 30 applications in leading mills—stock preparation, bleaching, water treating, conversion.

- **Bulletin 1253:**
  "Controlled Volume Pumps in Process Instrumentation."
  Describes use in open loop, closed loop, composite, special, and integrated chemical feed systems.

to get help

flow control problems:

send for these FREE *Milton Roy technical bulletins*

MILTON ROY—the name that stands out in *precision pumping* . . . for the latest, most advanced methods of accurate and dependable low-capacity flow control!

With (1) a full line of controlled volume pumps for all pressures, (2) new products coming off the line, (3) a wealth of application information on a variety of processes, and (4) complete engineering facilities and experience valuable to you . . . Milton Roy is in an ideal position to offer you really practical service. You can depend on Milton Roy to help you solve your specific low-capacity flow control problem . . . simple or highly complex.

Milton Roy has published a number of important bulletins describing the "new approach to flow control." Any of them are available to you for the asking. Clear text and diagrams illustrate the use of controlled volume pumps in a variety of flow control applications. One of these informative technical bulletins may well contain the precise solution to the problem that has been plaguing your plant or process. It will pay you to check.

Engineering representatives in the United States, Canada, Mexico, Europe, Asia, South America, and Africa.

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CHEMICAL FEED SYSTEMS

Just fill in the handy coupon below. Check the bulletins you want. Milton Roy will send you this valuable technical information without delay. There's no obligation.

BE SURE TO SEE IT
at the Milton Roy exhibit, "10th Annual Instrument Conference," Sept. 12-16, Shrine Exposition Hall, Los Angeles, *Booths A-112 and A-113.*

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1300 East Mermaid Lane, Philadelphia 18, Pa.

Please send me the bulletins checked:

☐ Bull. 755	☐ Bull. 555	☐ Bull. H20-1
☐ Bull. 953	☐ Bull. 455	☐ Bull. 1253

*Name*_____ *Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

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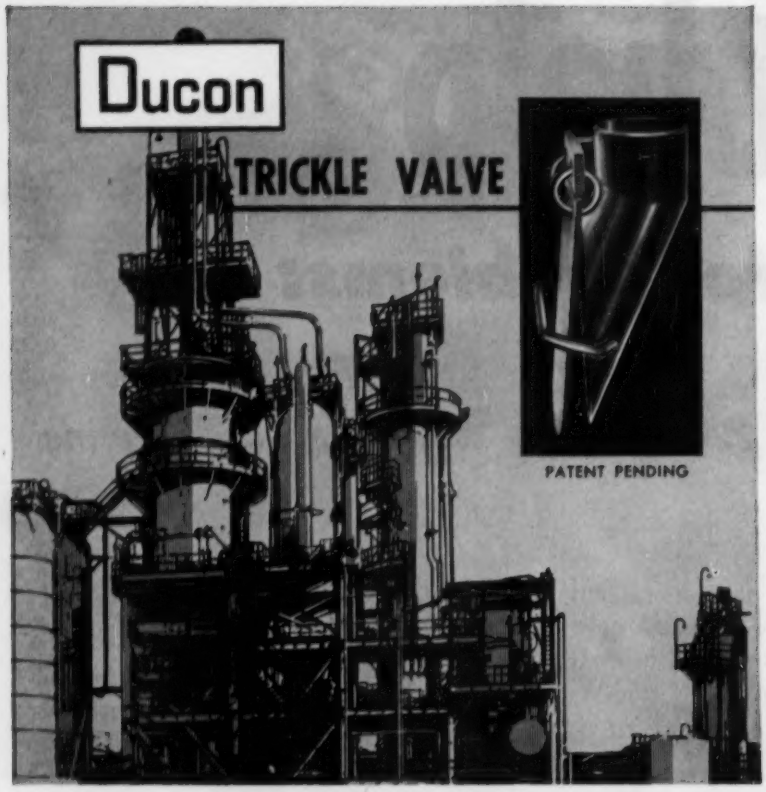

. . . the first dip-leg SEAL with approval for fluid catalytic cracking plants

Ducon's trickle valve has been *approved* throughout the refining industry, as a "fool-proof" dip-leg seal. Here is the result of years of specialized experience . . . the kind that pioneers progress . . . the kind that has earned for Ducon recognition as a leader in the field of catalyst and fluid solids recovery.

Over 500 trickle valves already in service are proving the effectiveness of the following features:

COMPLETELY AUTOMATIC DIP-LEG SEAL
MINIMUM CATALYST LOSS AT START-UP
ASSURANCE OF DIP-LEG SEAL DURING UPSET
ELIMINATES ALL ADDITIONAL AERATION
MAINTENANCE-FREE CONTINUOUS OPERATION

Write for Bulletin

the name in dust control

Canadian Branch: THE DUCON COMPANY of CANADA, Ltd.
275 James Street North, HAMILTON, ONTARIO

THE Ducon COMPANY

147 EAST SECOND STREET, MINEOLA, N.Y. • Sales Representatives in Principal Cities

Designers and Manufacturers of Dust Control Equipment Exclusively

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

As Management Sees It . . .

weight as possible on the extent of education. It was realized that a supervisor would be hard put to make a fair comparison between an employe with a Ph.D. degree and one with a B.S.

It was decided that the best approach would be a comparison of each man against his own job, with an additional yardstick to measure promotability.

The first step in devising an actual, workable form was a study of the literature on ratings of professional and supervisory people. It was found that little had been done along this line.

Next came a survey of forms used by other companies. This uncovered a widespread desire to develop personnel and to measure promotability.

There followed a survey of work situations in Phillips' Research and Development Department. Members of The Employe Relations Section talked to supervisors, employes and members of top management to determine what was considered important in a research and development atmosphere.

The result was a rough draft of a form which was subsequently revised by a committee composed of department management and employe relations people. The revised form incorporated their ideas and criticisms.

The first evaluation was held on a trial basis in order to gain time to study the form and the program. Work supervisors did the evaluating because of their close association with the individual employes. After each evaluation the completed form was reviewed by the supervisor immediately above, which had the effect of a rating by two men at a minimum cost in time.

Before any evaluations were made the supervisors concerned were put through a training session. The meaning behind the form was explained and the objectives outlined. Toward the goal of consistency, the supervisors were thoroughly informed on the meaning of the various sections and the traits to be evaluated. A manual of instructions was prepared in great detail. Employe Relations personnel gave assistance to those supervisors who felt they had problems not clearly explained in the training sessions or covered in the manual.

After completion of the trial evaluation complete reports were presented

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Catalysts

GIRDLER DESIGNS... ENGINEERS AND BUILDS PLANTS

...FOR purifying liquid or gaseous hydrocarbon mixtures

...FOR recovery of sulphur from hydrogen sulphide

How you benefit from GIRDLER leadership in catalyst technology

HIGH QUALITY Girdler catalysts enjoy industry-wide recognition as the answer to many tough catalyst problems. Girdler manufactures many types of catalysts for a wide range of processing applications. Our experienced catalyst technicians are well-qualified to work with you to prepare catalysts to meet your specifications. Or, if preferred, we will take your formulae and *tailor-make* catalysts to *your* exact requirements.

Why not take advantage of Girdler's experience in solving catalyst problems? Call the nearest Girdler Office today. Write for bulletin, "Physical and Thermodynamic Properties of Elements and Compounds".

the GIRDLER Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY
GAS PROCESSES DIVISION: New York, Tulsa, San Francisco.
In Canada: Girdler Corp. of Canada Ltd., Toronto

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As Management Sees It . . .

to management with the aim of acquainting them with results, inviting their criticisms, and ascertaining their opinion as to whether the evaluation effort was worthwhile. The reports included abstracts of each individual form and promotability charts by sections. The latter enabled the branch and division managers to determine at a glance just who was promotable, who wasn't doing well, and who should be given assistance.

After studying the reports, the management committee met with employe relations personnel and offered criticisms. These were incorporated in the form, another meeting was called, and there emerged a final form that met with the approval of a large part of the supervisory personnel.

More training sessions were held with evaluating supervisors. Revisions in the form were explained to them and the reasons why they were made. The majority of the supervisors agreed that they had been benefited by the trial evaluation.

Upon completion of the formal performance evaluation program, the evaluating supervisors held conseling interviews. Employes aired their grievances and supervisors made necessary criticisms in "talk-it-over" sessions which brought out problems that would have remained hidden in the ordinary work situation.

To determine how the programs were being received by employes, the Employe Relations Section conducted a survey. Through questionnaires, employes were asked what they thought of the program and if they had a better understanding of "where they stood." Replies left no doubt that they approved.

It is planned to make performance evaluation a continuing effort. Once a year professional employes will be evaluated and have a counseling interview. The routine may be varied later to allow longer intervals between evaluations of older men while continuing the annual evaluation of new personnel.

The Employe Relations Section feels that the program's success is basically due to two factors: First, the inclusion of supervisors in the actual work of devising the form and program; and second, the counseling program which followed the evaluation.

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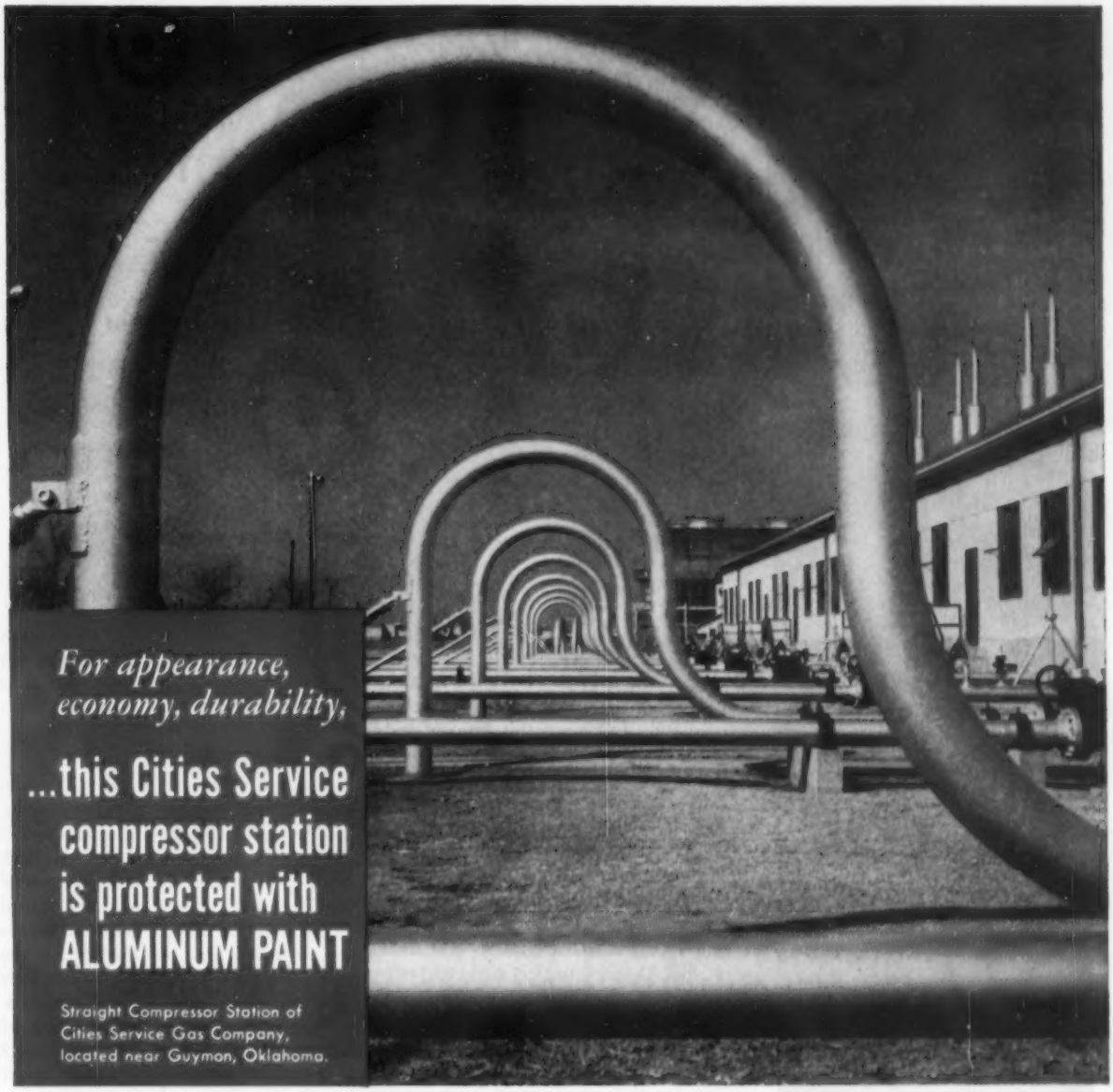


For appearance, economy, durability,

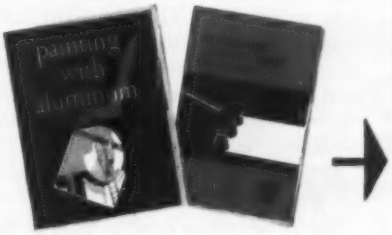
...this Cities Service compressor station is protected with ALUMINUM PAINT

Straight Compressor Station of Cities Service Gas Company, located near Guymon, Oklahoma.

Cities Service gives three good reasons for specifying aluminum paint—beauty, durability and economy. For instance, aluminum paint improves appearance. Its bright, clean look is preferred throughout industry.

Aluminum paint is economical, too. It costs no more (frequently less) than other paints, yet provides unmatched qualities of durability. These reasons, drawn from Cities Service's own long experience, tell why aluminum paint has become the most practical . . . most popular paint in the natural gas and petroleum industry.

ALCOA does not make paint . . . but ALCOA Aluminum Pigments are used in more aluminum paints than any other brand. ALCOA's cooperation with paint manufacturers has made possible many special formulas designed to solve your toughest problems. Write us about your paint problems or mail the coupon today for our FREE BOOKLETS.



ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Paint Service Bureau, Aluminum Company of America
1793-J Alcoa Building, Pittsburgh 19, Pennsylvania

Please send me your FREE BOOKLETS:

- ☐ Painting With Aluminum
- ☐ Aluminum Asphalt Roof Coatings Make Time Stand Still

Name_____

Company_____

Address_____

City_____ Zone____ State_____

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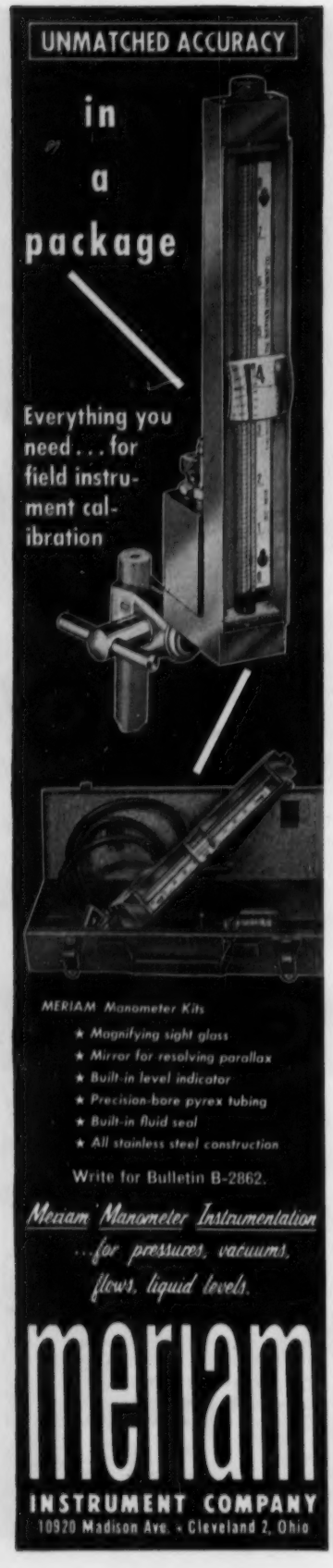
UNMATCHED ACCURACY
in a package
Everything you need... for field instrument calibration
MERIAM Manometer Kits
★ Magnifying sight glass
★ Mirror for resolving parallax
★ Built-in level indicator
★ Precision-bore pyrex tubing
★ Built-in fluid seal
★ All stainless steel construction
Write for Bulletin B-2862.
Meriam Manometer Instrumentation
...for pressures, vacuums, flows, liquid levels.
meriam
INSTRUMENT COMPANY
10920 Madison Ave. • Cleveland 2, Ohio

As Management Sees It . . .

Safety Needs Promotion

Occasional safety campaigns are not enough. Safety is a continuing goal and must be continuously promoted. Here are some hints that will help you.

J. E. Bedford, Professor of Management,
Armstrong College,
Berkeley, Calif.

A REVIEW OF the safety record of any refinery will reveal that the accident rate goes down during a safety training program. It is held down immediately following this type of program. Then, suddenly, accidents will start to happen all over. The accident rate will then be as high or higher than it was before the safety program was put into effect.

Why?

Usually it is because the newness of the program has worn off. Workers and supervisors have fallen into their old habits; they neglect to keep practicing the rules covered in the initial safety training program.

When the accident rate starts to climb, refinery management is apt to consider the safety program a waste of time and money and cast it aside. This may pare a few dollars from the evident overhead expense, but the hidden cost of accidents will remain—lost time, lower production, extra repairs, and lower employe morale.

Progressive refinery management does not stop the sales promotion and advertising program when business starts to decline. They put more effort into promotion. This may include more aggressive selling, sales contests, more extensive advertising, selecting a new theme or slogan for the advertising, or offering extra commission for the salesmen.

Whatever is done it is promotion—not stopping!

Safety programs need a "shot in the arm" to keep them at top efficiency and to keep the accident rate at a low level. Here are some ideas helpful in promoting a refinery safety program:

1. Bulletin Boards.

Safety posters can be purchased in quantity for use on bulletin boards. However, this type of poster usually falls into a standard pattern. A check with employes the day after the poster has been changed will not reveal much identification or interest. Workers form a habit of tuning out the standard safety poster just as they tune out radio and TV commercials.

Part of the reason for this lack of interest in the prepared safety posters is that they lack refinery human interest. The people pictured on the poster are not known to the people in the refinery. The scenes illustrated may be for an accident in a steel mill or a tire plant and lack petroleum industry identification necessary for arousing the interest of the workers in the refinery.

However, when this poster idea is changed to a poster of an accident in your refinery, a photograph of one of your men who has an enviable safety record, or a picture of one of your refinery trucks in an accident, the workers will read and remember the safety poster. This will have refinery human interest—your refinery.

Here are some suggestions to get the most value from your posters:

- Change the posters frequently—

 For more data on advertised products, use Readers' Service Cards, last page.

BETZ • *A Great Name In Water Conditioning*

Consulting is a full time job, too!

In our continuing efforts to engineer sound water conditioning for industry, our service activities extend into many phases of this exacting field.

The Betz Consulting Division, for example, is typical of the completeness and diversification of the service we offer.

This separate unit of the organization, staffed with qualified chemical, mechanical and sanitary engineers, provides full-scale engineering services on a variety of problems relating to the *external* conditioning of industrial water for process, cooling, and boiler feed requirements, and the treatment of industrial waste and sewage.

Whether the water or waste problem is of broad or limited scope, the Betz Consulting Division matches *service* to *need* through its many activities such as

. . . economic and technical surveys . . . chemical engineering research . . . pilot plant design and operation . . . equipment specification and procurement . . . process design and supervision . . . start up operation . . . continuous supervisory service.

This specialized consulting service is *another* reason why Betz continues its leadership in providing completely-integrated engineering on all water problems.

Ask a Betz District Engineer the next time he calls how Betz Consulting Service can help you solve *your* water problem. He'll be happy to provide the details.

W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: BETZ Laboratories Limited, Montreal 1.

BETZ

CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

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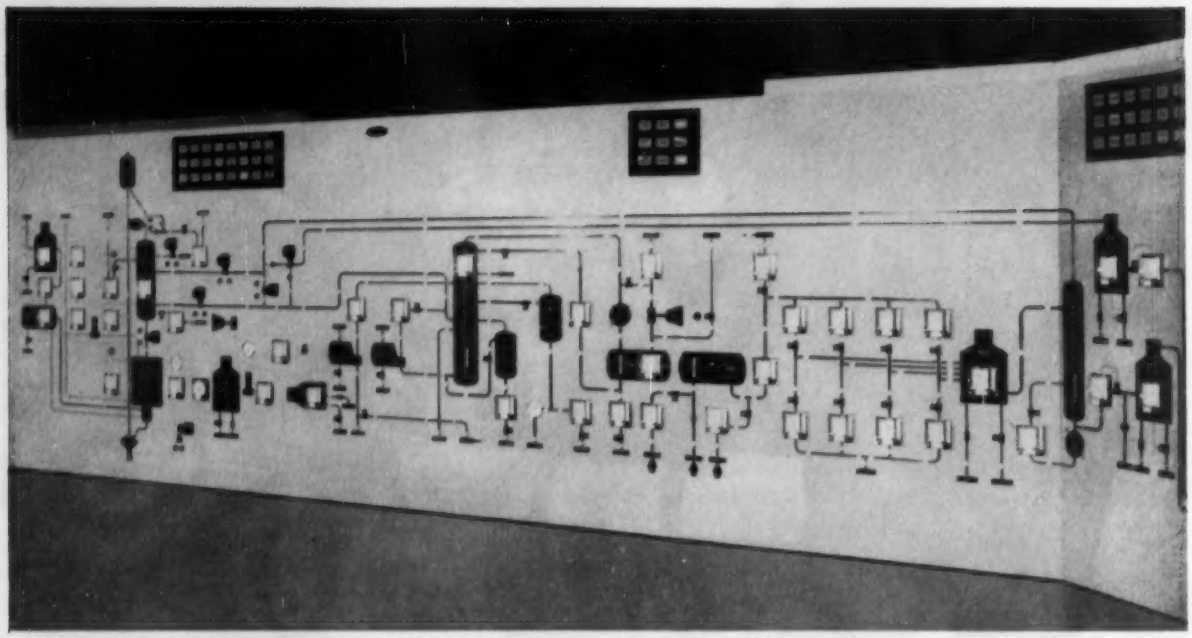
BRISTOL'S
Metagraphic Receiver line



THIS TYPICAL GRAPHIC PANEL OF BRISTOL METAGRAPHIC INSTRUMENTS IN AN OIL REFINERY FEATURES:

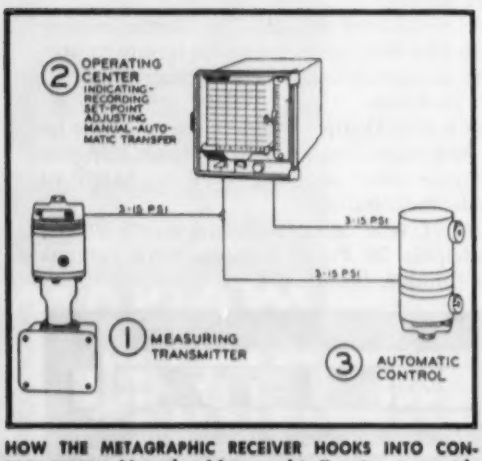
Human engineered, scientifically designed scales for error-free close-by, as well as distant, readability.

Molded clear plastic doors improve visibility to the limit – no shadows or reflections.

All measurements are on the same scale plate.

The instrument presents readings to the process operator in the most easily grasped form. High-visibility, colored fluorescent paints are used on pointers to enable operators to easily tell them apart. All pointers for a given function are the same color in all instruments.

A new degree of performance, flexibility, and ease of servicing in a pneumatic receiver



HOW THE METAGRAPHIC RECEIVER HOOKS INTO CONTROL SYSTEM. Note that Metagraphic Receiver is *outside* the control loop. As a result, unplugging the receiver creates no transient disturbance in the control loop.

FULL PLUG-IN SERVICE: The chassis of a Metagraphic receiver is built for full plug-in service. It is of one-piece construction and can be withdrawn to an intermediate position for servicing, without interrupting its operation, or completely removed from the case (no tools required).

Flexibility. Full plug-in construction provides a flexibility of use that can't be matched. A recorder can be changed to an indicator or vice versa in less than 10 seconds by merely replacing chassis. One model can be changed to another or, if trouble is suspected, the doubtful unit can be replaced by a spare.

No interruption whatever to automatic control when receiver chassis is removed. The set point and manual-automatic transfer station are part of the receiver case. With the chassis removed from the case the controller functions as a blind controller. You get the same automatic control with chassis removed.

When a recorder chassis is replaced the chart can be easily removed and put on the new chassis.

Ease of servicing. Little or no maintenance is required. Simplicity of construction and plug-in feature make it possible, if trouble is suspected, to check receivers while they are still in operation by pulling chassis out to the intermediate position

gives you 35 models to choose from

where it can be inspected, charts changed, pens inked, zero adjusted, and clocks serviced. A receiver suspected of giving trouble can be replaced in a few seconds with a stand-by unit and checked and serviced in the service shop – out of service time is thus eliminated.

Anybody can learn to check and service a Metagraphic Instrument in a few minutes.

CONTINUOUS VALVE POSITION INDICATION on same instrument scale plate as set point scale gives continuous data on control valve position – makes "bumpless" transfer possible, simply by matching pointer positions – no need to read actual scale values – minimizes reading errors – speeds operations.

IDEAL FOR GRAPHIC PANEL AND CONSOLE USE: More instruments can be mounted in a given panel area than with any other type of receiver.

They fit into a 4-9/16" square cut out – no notches required.

They mount 6-1/2" center to center on panel (6-1/2" and 7" with controller plugged into receiver case).

SCALES ARE SCIENTIFICALLY DESIGNED for instant, error-free readability – a new degree of close-up, as well as distant, readability. Control information can be obtained at a glance at distances up to 20 feet by noting whether pointers match – no need to read scales.

OFFERED FOR UP TO 3 MEASURED VARIABLES – With air pressure regulators or air-loaded regulators, three-position manual-automatic transfer valves for automatic control, and six-position (on same knob) transfer valves for cascade control.

ALL MEASURING ELEMENTS in receiver are the same high quality and accuracy. They all indicate on the same scale plate.

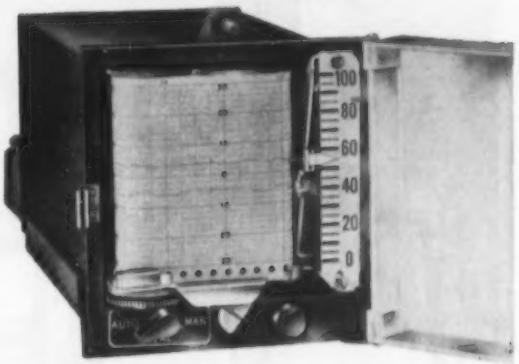
AIR CHART DRIVES are 100% pneumatic operated – no electricity is needed in control room for clock – operates off 20 psi air supply.

UNIVERSAL PIPING MANIFOLD can be adapted to any piping (2-pipe or 4-pipe system). Only a screw driver and wrench needed – no parts required.

HIGH-VISIBILITY COLORED FLUORESCENT PAINTS are used on pointers so operators can easily tell them apart. Pointers for a given function are the same color in all instruments. Control information can be obtained at a glance at distances up to 20 feet by noting whether pointers match or have deviated from each other – no need to read scales.

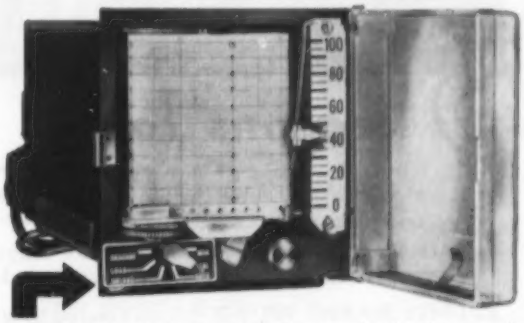
Write for the Bristol Metagraphic Receiver bulletin. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. 5 31

TWO-PEN RECORDING RECEIVER



THIS METAGRAPHIC TWO-PEN RECORDING RECEIVER, with Manual-Automatic Station records, indicates, and controls one measured variable, records one related variable on the same chart, and gives a continuous indication of either set-point or valve-position whichever is desired. If valve position is chosen to be continuously indicated, set-point may be indicated by depressing the valve knob or vice versa. The two recorded variables are at *no time* disturbed.

SIX-POSITION TRANSFER VALVE



SIX POSITION TRANSFER VALVE (on one knob) for cascade control.

Metagraphic instruments measure, record, indicate and automatically control:

Pressure	Liquid Level
Vacuum	Flow
Absolute Pressure	Temperature and
Differential Pressure	Mechanical Motion

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

BARCO Swing Joints and Assemblies

5 Reasons for SUPERIORITY!

1. **BALL BEARING AND O-RING EQUIPPED**—Designed specifically for handling gasoline, oil, lube oil, LP gas, petro-chemicals, and other petroleum products.
2. **LARGE BEARING SURFACE**—Barco's bearing design provides adequate support for lengths of piping. Minimizes bearing pressures and wear.
3. **CONTROLLED TORQUE**—No annoying, uncontrolled swinging of lines. They swing easily but stay put.
4. **LONG LIFE**—New "Bar-Moly" dry lubricant process gives a permanent anti-galling, corrosive-resistant finish to moving parts. This, combined with routine lubrication, insures longest possible maintenance-free service.
5. **EASY MAINTENANCE**—Joints can be disassembled for inspection without disconnecting piping. O-rings are easily renewable in the field. Frequent greasing not required to maintain sealing.

The Barco line is complete with single swing, double swing, and counter-balance styles and assemblies to meet every need. Sizes 1", 1¼", 2", 2½", 3", 4". All steel or malleable iron. Send for latest Catalog No. 400 containing engineering and ordering information. *Worldwide sales and service.*

BARCO MANUFACTURING CO.
542K HOUGH STREET
Barrington, Illinois

As Management Sees It . . .

at least every two weeks.

- Picture current accidents—not ancient history in your refinery.
- Have the poster tell the story—who, what, why and how the accident could have been prevented.
- Keep copy on safety posters at a minimum—people do not have or take time to read a long message.

2. Personal Letters.

Every time the safety record of a refinery worker is reviewed, it is suggested that the safe working employes receive a personal letter from a top executive. This can be a short note of congratulations to each employe who has gone through the period—six months or a year—without an accident.

These letters can follow a form, yet be made personal by a review of each individual's long standing safety record. If the employe received a safety letter a year ago, for instance, the second letter might start something like this:

"Last year when I wrote you about your fine safety record, I sincerely hoped that I would be able to send you another letter this year. You have gone two years without an accident! Congratulations, John."

If you have a limited number of employes in your refinery, you may find this form of stimulation best when the letter is delivered to the home of your safety-minded worker. It helps the family realize how important safety is considered where the husband works.

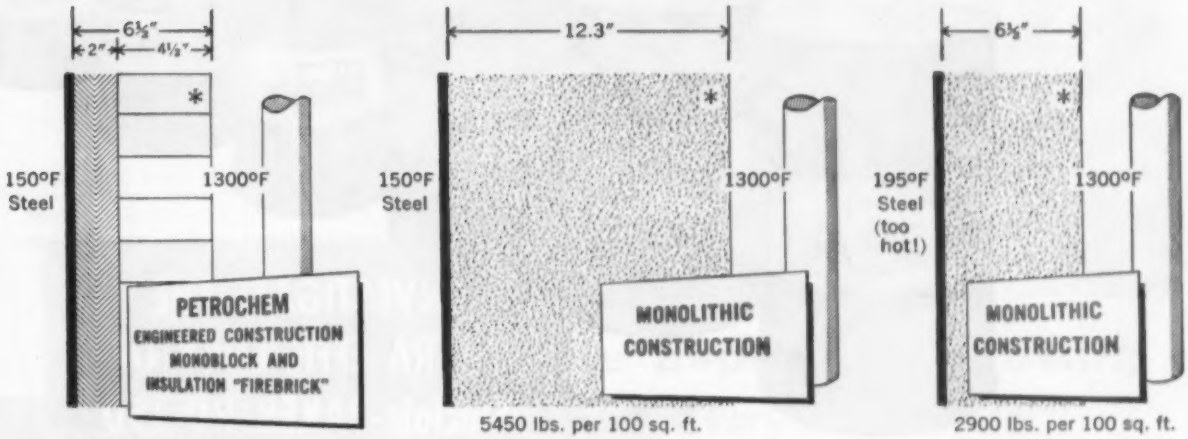
You may want a more frequent system of writing to your new employes. Statistics prove that new workers are more accident-prone than older workers. Thus, new employes receive a letter when they start, after a month, three months, six months, nine months, and one year. After this time the new worker is placed on the regular roles of safe workers.

Under this plan, employes who have had a serious lost-time accident receive letters of congratulations when they return to work, after a month, and again three months later. It is not because these workers need a reminder, but they will talk safety at lunch, be more observant of other

In furnaces as in processes compare the design to judge the advantages

As an example:

The wall construction of all Petrochem-Isoflow Furnaces is designed for 150°F maximum outside shell temperature.



1250 lbs. per 100 sq. ft.

5450 lbs. per 100 sq. ft.

2900 lbs. per 100 sq. ft.

*Based on B & W values.

The Petro-Chem design provides a thoroughly engineered wall construction. It is built with two tiers of monoblock supported on 18 inch centers and a circular arched wall of insulating firebrick. The inside of the steel shell is protected from the possibility of corrosion by a one-eighth inch thickness of Staylastic cement. This type of construction, independently supported monoblock and the circular arch of firebrick, bonded with Smoothset mortar, assures optimum efficiency and minimum maintenance.

The use of monoblock and insulating firebrick laid as a circular arch provides many advantages over a one-piece monolithic lining, including:

1—Low weight, 2—Low heat conductivity, 3—High hot crushing strength, 4—Low expansion coefficient, 5—Resilient compressible backing, 6—Long life, 7—Nil maintenance.

Also, this construction has low heat storage capacity, speeds both heating and cooling. Its light weight requires less concrete foundations and steel supports.

Compare and your judgment will affirm
Petrochem-Isoflow Furnaces are Most Efficient by any Comparison

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

Representatives: Bethlehem Supply, Tulsa and Houston • Flagg, Brackett & Durgin, Boston • D.D. Foster, Pittsburgh • Faville-Levally, Chicago • Lester Oberholtz, Los Angeles • Gordon D. Hardin, Louisville • Turbex, Philadelphia

International Licensees and Representatives: SETEA—S.A. Comercial, Industrial, y de Estudios Tecnicos, Buenos Aires, Argentine • Promotora Nacional De Industrias, S.A., Caracas, Venezuela • Firma Dr. C. Otto & Comp. G.M.B.H., Bochum, Germany • Birwelco Ltd., Birmingham, England • Societe Anonyme Heurtey, Paris, France • Societe Anonyme Belge, Liege, Belgium • Heurtey Italiana S.P.A., Milan, Italy

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IF YOU ARE CONCERNED WITH HIGH OCTANE OPERATIONS

INVESTIGATE THE EXTRA EFFICIENCY OF Sinclair-BAKER RD 150 PLATINUM CATALYST

BAKER'S RD 150 Platinum Catalyst is a joint development of Baker & Company, Inc. and Sinclair Research Laboratories. This peak-production catalyst is now used with marked advantage by such companies as Sinclair, Socony and Pure Oil.

REGENERATES IN SITU . . . !

RD 150 provides high initial efficiency plus unique regenerative features. RD 150 assures greater yields at high octane levels, exceptionally long periods of operation, PLUS additional economy made possible by regeneration in situ! We are quite confident that the full story of Baker's RD 150 will be intensely interesting to you.

You can also be relieved of delivery and service problems. Modern Baker plants are geared for large-scale manufacture and refining of platinum catalyst.

Upon request, a Baker representative will be glad to consult with you and to furnish detailed information and recommendations.

BAKER & COMPANY, INC. CATALYSTS

113 ASTOR STREET · NEWARK, N. J.

THE HUB OF PLATINUM METALS RESEARCH

workers' unsafe practices, and be good on-the-job safety trainers for new employes.

Another plan for these letters is to send one to the men in one department and another to employes in another department. Thus, the entire department is congratulated for its safety record and this starts a form of rivalry between the two departments to establish the best safety record.

Refinery management using personal letters to stimulate safety will want to consider the following rules:

- Don't use a mimeographed form letter—make it personal or don't send it.
- Tie-in with past safety letters to make the congratulations more personal and more sincere.
- Work out a system so that none of the employes are overlooked in this safety letter program.

3. Contests and Drawings.

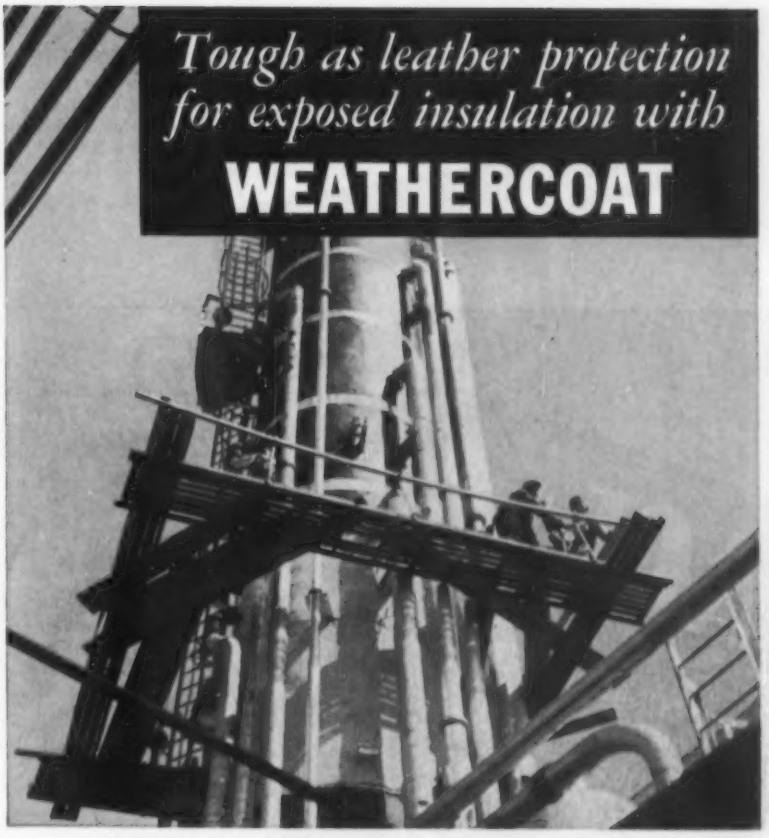
Safety contests have been used in many refineries with a variety of results. If the contest is successful in keeping the accident rate at zero for any period of time, the contest drags on for months. Employes tend to lose interest after a month or so and the value of the safety contest is lost.

However, if the accident rate is particularly high in a refinery, the contest can be used for a short time to provide a stimulant to get things on an even keel. Then, after the contest has run for 30 days, the awards can be made. This will eliminate long waiting and the lack of interest that may develop.

Another form of contest is a weekly safety drawing. Management puts up a weekly safety award in cash. The amount will vary with the number of employes and the seriousness of the accident rate in the refinery. Each week the workers who have had 60 accident-free working days are entered in the drawing.

After a worker has had an accident, he must maintain a 60-day safety record before he can participate in the weekly drawing. This keeps everyone safety-conscious and ties in with the payroll pools that have developed in many refineries.

A variation of this weekly drawing is to eliminate all workers when there is an accident in the department or division. Thus, all employes in the di-



. . . the asphaltic coating that stays "ALIVE"

Thermal insulation on outdoor operating facilities needs a "raincoat." This material depends upon small air spaces formed by the flake fibers, or spheres of solids in the insulation itself to retard the flow of heat (or cold). Should moisture fill all or part of these air spaces the efficiency of the insulation would be seriously affected.

Weathercoat gives lasting protection. Weathercoat has an extremely high resistance to moisture in all its forms. (It has a Perm rating of 0.0175 for 0.10" thick dry film.) It is a factory compound of asphalt emulsion and mineral fillers and fibers that sets to a smooth, tough and pliable finish. Because no clays or other hydrophilic fillers are used in Weathercoat, it stays "alive." This assures long-lasting protection for insulated surfaces.

Nation-wide acceptance. Many of the largest refineries, chemical plants, and power stations in the nation are regular users of Weathercoat, both for maintenance and for new construction. During the last year alone, over 5 million sq. ft. of insulation have been coated with Weathercoat. The Laykold Engineer in our office nearest you will supply full details.

AMERICAN Bitumuls & Asphalt COMPANY

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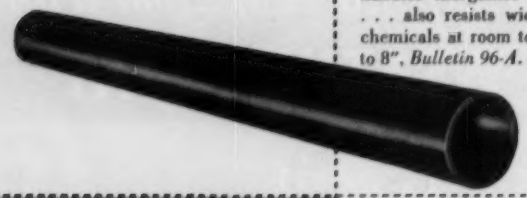
San Juan 23, P.R.

For more data on advertised products, use Readers' Service Cards, last page.

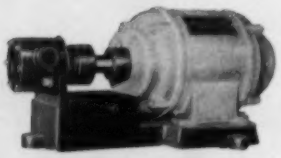
FOR HOT CORROSIVES:
ACE TEMPRON

Heat-resistant nitrile hard rubber pipe handles inorganics at 250-275 deg. F. . . . also resists wide range of organic chemicals at room temperature. Sizes 1" to 8", *Bulletin 96-A.*

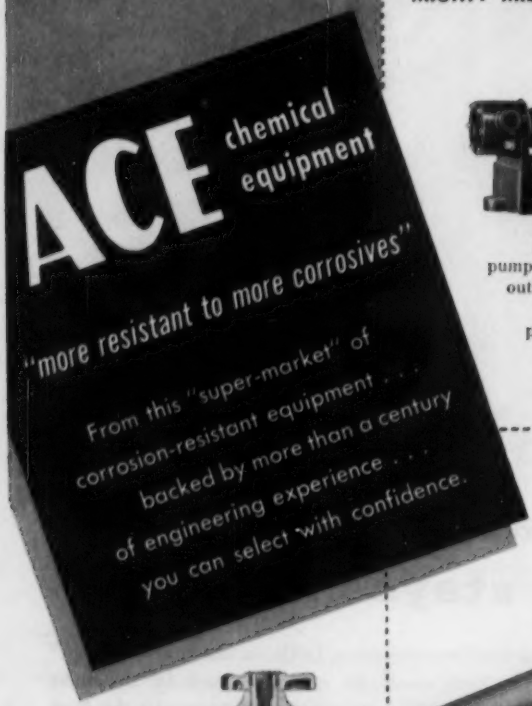


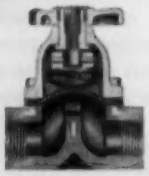
MIGHTY MIDGET

for pumping acids



Jabsco neoprene-impeller pump made of ACE hard rubber outlasts, out-pumps anything in its pressure, size and price class. Capacity from 15 gpm. at 22 ft. head to 5 gpm. at 72 ft. head. *Bulletin 97-A.*

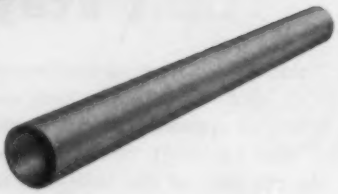

ACE chemical equipment
"more resistant to more corrosives"
From this "super-market" of corrosion-resistant equipment . . . backed by more than a century of engineering experience . . . you can select with confidence.



VALVES

for all-plastic piping systems

Trouble-free plastic diaphragm valves . . . choice of general-purpose rubber-plastic blend, Ace Parian (polyethylene) or Ace Saran. Handles most corrosive chemicals and food ingredients. Sizes ½" to 2", 50 psi. at 77° F. *Bulletins 80 and 351.*



TOUGH ACE-ITE PLASTIC PIPE

General-purpose moderately priced rubber-plastic pipe handles most common chemicals to 170 deg. F. . . . except few strong acids and organic solvents. Tough, odorless, tasteless. Rigid pipe ½" to 6". *Bulletin 80.*

ACE rubber and plastic products

AMERICAN HARD RUBBER COMPANY
93 WORTH STREET • NEW YORK 13, N. Y.

As Management Sees It . . .

vision suffer when there is an accident. Safety is a topic of conversation, observation, and activity all the time.

Still another variation of the weekly safety drawing is to award a nominal prize to all employes with a work number ending in the number drawn. For instance, the number seven might be drawn and all employes whose work badge ends in seven receives a dollar safety award.

Best results are obtained when the contests and the drawings follow these suggestions:

1. Keep the time limit of the contest under 30 days and drawings on a weekly basis.
2. Make the rewards worth while to build greater worker enthusiasm.
3. Post contest results or names of drawing winners as soon as possible.
4. Emphasize safety in all activities connected with the contest or drawing.

These three methods of promoting safety are by no means the complete list, they represent ideas that you may find helpful. Variations of these ideas and other methods of promoting safety can be developed from these basis idea-starters.

Refinery management that has a keen desire to maintain a low accident rate will find plenty of ways to remind the workers and supervisors that safety is everyone's problem—every day. ##

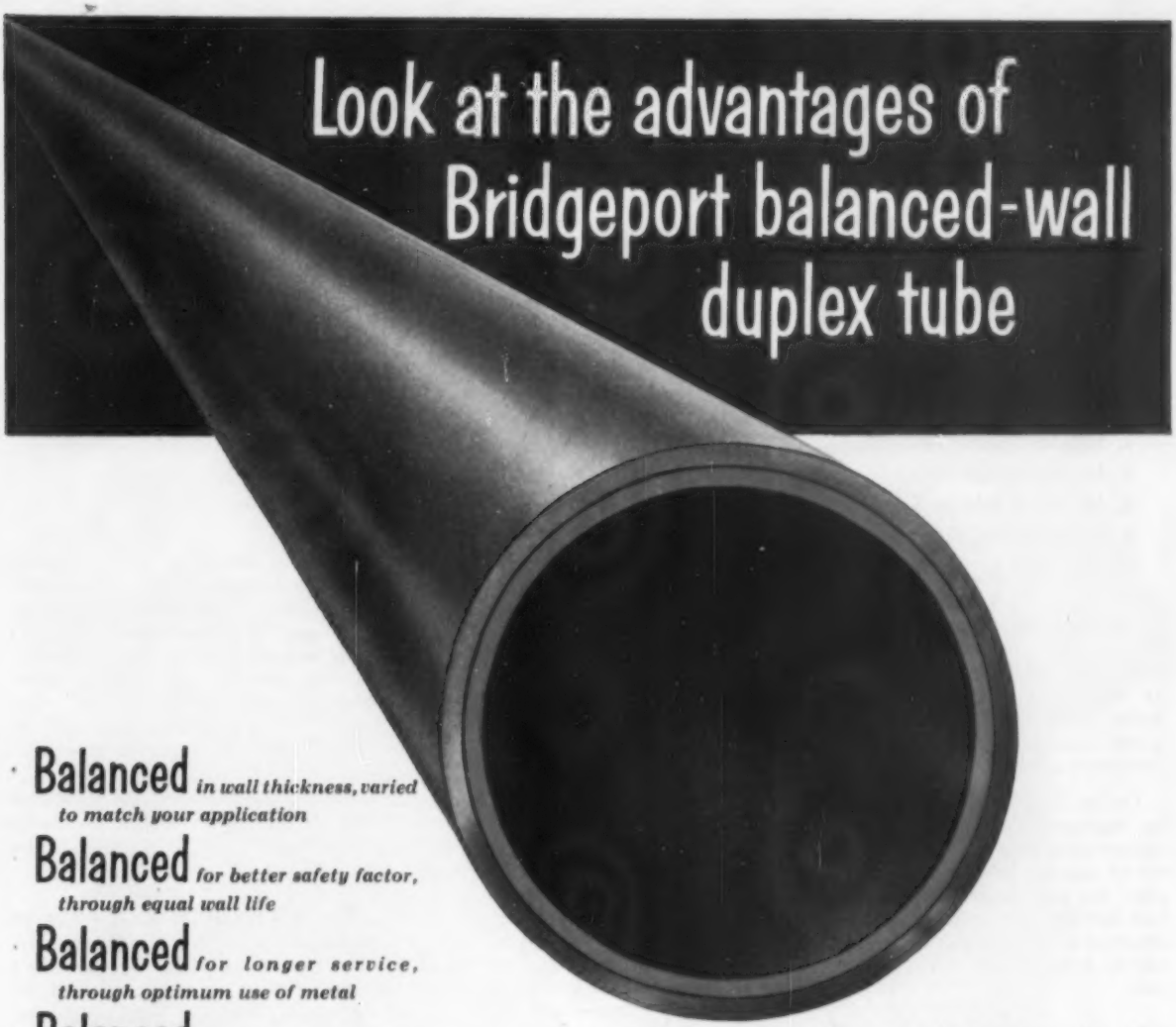
CHEMICALS WANTED

The National Registry of Rare Chemicals, Armour Research Foundation of Illinois Institute of Technology, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

3-(Octadecyloxy)-1,2-propanediol (Baty alcohol)
p-Xylene-alpha,alpha'-diamine
1,3,5-Trivinyl benzene
Technecium chloride
Trinitrosophloroglucinol
Methyl phosphite
2-(n-Butyl)pyridine
1-Octadecylpyridinium chloride
2-Methylglutamic acid
2,4-Dimethyl-1-hexene
2,4-Dimethyl-2-hexene
3,4-Dimethyl-1-hexene
3,4-Dimethyl-2-hexene
2,3,4-Trimethyl-2-pentene
3,4,4-Trimethyl-1-pentene
3,3-Dichloropropene
4,5-Dimethyl-o-phenylenediamine
2,4-Diamino-5-phenylthiazole hydrobromide
9-Amino-nonanoic acid

For more data on advertised products, use Readers' Service Cards, last page.

Look at the advantages of Bridgeport balanced-wall duplex tube



- **Balanced** *in wall thickness, varied to match your application*
- **Balanced** *for better safety factor, through equal wall life*
- **Balanced** *for longer service, through optimum use of metal*
- **Balanced** *in metal specification to resist different types of corrosion, inside and out*

Bridgeport Duplex Tubes are available in many combinations of copper-base alloys with steel, aluminum and other metals. Lifetime Costs Are Lowest With Bridgeport Duplex Tubing.

Before specifying any heat-exchanger tubes, consider these facts: The job of each Bridgeport Duplex Tube is analyzed and gauges are calculated so that both inner and outer tubes will attain the same long life. The wall thickness of the component tubes in Duplex is varied to meet your specific application needs as influenced by temperature, pressure, corrosion rate on the inside and outside. You are assured a *balanced-wall* Duplex Tube, with improved safety factor, which makes practical use of every ounce of metal.

Another important benefit is the superior heat-transfer properties of Bridgeport Duplex Tube, achieved by a closer, cleaner bond on the interfaces. And, of course, by resisting different types of corrosion inside and out, they eliminate or reduce the need for frequent retubing and shutdowns, and reduce maintenance costs substantially.

Add up all these advantages, and you see that Bridgeport Duplex Tubes give consistently superior performance *and* lasting economy over a period of time. Remember, it's lifetime costs that count and Bridgeport Balanced-Wall Duplex Tubes assure lowest lifetime costs. Our Technical Service Department will be glad to recommend Duplex Tubes to match your individual service requirements.

Call your local Bridgeport Sales Office for complete information. Ask for Bridgeport's Duplex Tube Technical Bulletin.

Bridgeport Brass Co.

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Bridgeport Brass Company, Bridgeport 2, Connecticut • In Canada: Noranda Copper and Brass Limited, Montreal

For more data on advertised products, use Readers' Service Cards, last page.

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3. Fiberglas & Asbestos Wraps
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Counteracting corrosion of underground pipes can mean tremendous savings for your company. As part of its famous "one for all" service, ToPaz distributes the complete Holcombe Company line of pipeline protection equipment and supplies.

You can trust ToPaz for high quality, dependable corrosion prevention equipment at all times. Contact ToPaz for all pipeline equipment and supplies. You can depend on ToPaz for fast delivery and prompt, personal attention to your order. You'll get the job done faster with ToPaz helping you.

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How to Build Presenteeism

Worried about absenteeism? Thinking of offering cash awards? Or using the shame-them approach? Here's a better way. Find the X Factor in your organization.

Auren Uris,
Research Institute of America,
New York

MANAGEMENT people have burned a lot of midnight oil trying to work out remedies for absenteeism:

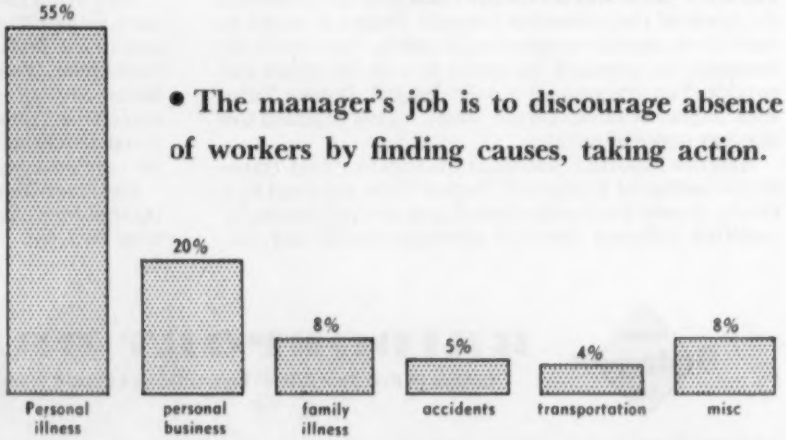
CASH AWARDS. One company developed a system of bonuses to employes for perfect attendance. But it caused trouble: Employes came to work when they *should have* remained home; a worker who *had* to stay out for a perfectly good reason developed a sour outlook on the whole thing.

THE "SHAME-THEM" APPROACH. The company posted the names of absentees on bulletin boards. Results were not satisfactory. Employes resented being held up to public ridicule.

THE SALT MINES. All-time record goes to the Soviet Union. In Russia, absenteeism gets the Siberia treatment.

Even this extreme penalty doesn't put an end to the problem. Absentees still add to the population in the labor camps.

Reasons and Figures—Studies of large numbers of absentees over periods of time generally give this kind of picture as to reasons for absence:



Statistics like these are interesting, though not always helpful. The trouble is, these figures often hide as much as they reveal. One man says he "couldn't come to work because of a headache." A week later he refuses to go home despite a temperature of 101—"because I've got an important job to finish." What accounts for contradictions of this kind?

Studies by psychologists show that there is an intangible factor causing absenteeism which frequently eludes the statisticians.

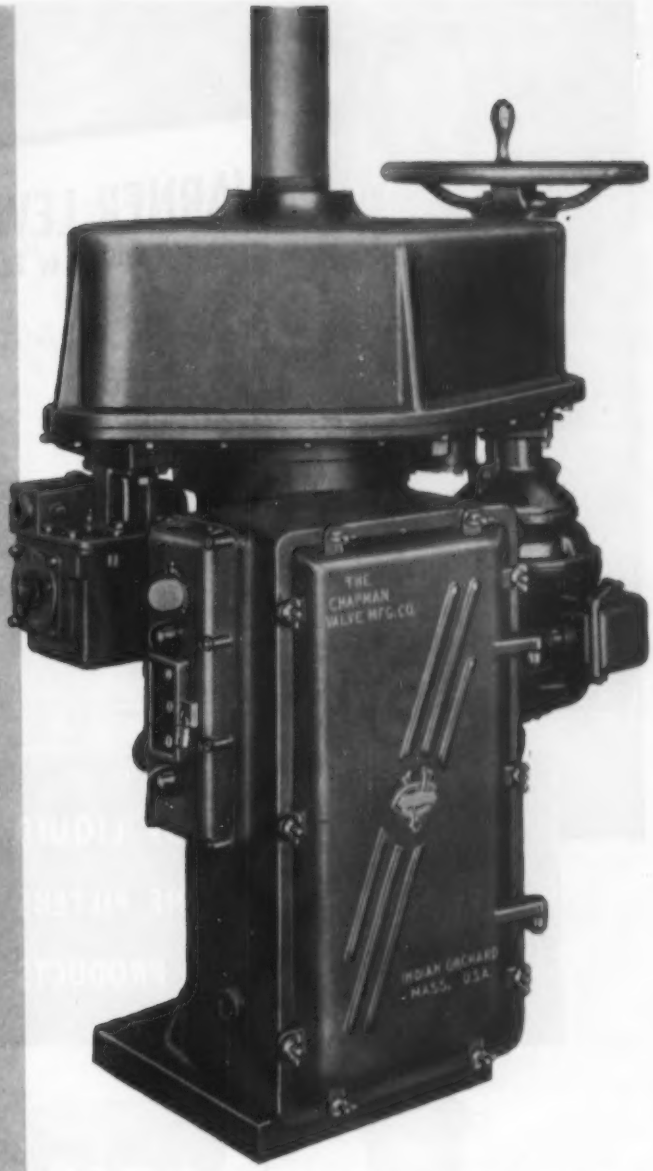
The X Factor—Bernard J. Covner in the *Harvard Business Review* relates the about-face in one company's thinking after it really studied its absentee difficulties. Management began by hoping it could find a "convenient means for getting rid of worst offenders, and preventing the hiring of potential offenders."

According to their view, absenteeism was a specific ailment, like shingles or athlete's foot, that afflicted certain individuals. The way to stop absenteeism, then, was simply to get rid of the

• The manager's job is to discourage absence of workers by finding causes, taking action.

Fewer Parts Mean Greater Dependability

Floorstand Motor Unit . . . control panel, motor, limit switch and push button station.



Simple, durable mechanism of Chapman's Motor Unit. Handwheel remains stationary during motor operation.

IN CHAPMAN MOTOR UNITS

Chapman's simple and rugged Motor Unit gives accurate, trouble-free control of large valves and sluice gates. It has approximately *half as many parts* as any other unit. Its simplified design, low speed motors and low-ratio, stubtooth gears combine to give positive operation without drift, in *any* position and under all conditions.

Installation is fast and simple. The floorstand unit comes completely wired, ready to connect to leads. Limit switch has micrometer adjustment for exact pre-setting for seating tightness. Motor Units operate smoothly under the most adverse conditions. All units are weather-proof and steam-tight. Write today for *new* Catalog 51.

The Chapman Valve Manufacturing Co.
INDIAN ORCHARD, MASSACHUSETTS

For more data on advertised products, use Readers' Service Cards, last page.

A COMPLETE LINE OF LIQUID SEPARATORS AND FINE FILTERS FOR LIGHT PETROLEUM PRODUCTS

EXCEL-SO D-Model Filter

HP-700 High Volume Separator Filters

FRAM Liquid Separator Filters

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The extensive research facilities and wide experience of FRAM and WARNER LEWIS COMPANY are now combined to provide scientific liquid separation and filtration for Refinery process streams, pipelines, and petroleum marketing installations.

Inquiries are invited on your particular problems.

DIVISION OF FRAM CORPORATION

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As Management Sees It . . .

"diseased" individuals.

Investigation, however, revealed that management factors — conditions largely within the control of management—were the main cause of avoidable absenteeism. Those elements can be called the X Factor—the psychological reason that accounts for absenteeism.

The X Factor is an integral part of the work scene—in your company, in every company. It figures in the conditions under which an employe does his work. And here we don't mean the lighting, or the color of the paint job on the walls. We're talking about the "emotional conditions," the feelings that exist among employees, and between supervisor and worker.

Many management men, as a matter of fact, can actually "feel" the presence or absence of the X Factor in a given department or company. A calm efficiency, an easy friendliness among the personnel shows the X Factor is present, as surely as the clicks of a geiger counter reveal radioactivity.

How do you build attendance-encouraging conditions on the job? A recent study of the relationship between attendance and department size, Table A, gives one revealing answer:

TABLE A

Number of Employes Working in Department	Percent of Employes Having 1 or More Absences per Month
1— 9	7.9
10—19	14.8
20—39	24.6
40 or more	30.2

According to these figures, the smaller a work group, the better its attendance. One likely reason is that the X Factor—good inter-personal relations—is more easily achieved in small groups.

The employes in a small unit tend to develop a stronger feeling of friendliness, of belonging to a team. An individual is more important on a five-man team than he'd be on a 20-man team.

Supervisor-Employe Relations—Actually, the ordinary day-to-day activity has a profound effect on the emotional atmosphere on the job.

Take the case of Arthur Sweet, getting out of bed on Monday morning. His wife is still asleep—just as tired as he is. The night before they had been at her sister's wedding and they had danced until two in the morning.

Sweet goes to the mirror to shave. He looks himself in a blood-shot eye, asks: "To go to work or not to go?"

How he answers that question will depend on the balance he strikes between the negative factors and the affirmative.

NEGATIVE: the bad taste in his mouth, the aching bones, the fuzzy head. If these were the only factors, he'd stay home.

But Arthur Sweet this Monday morning is a man with a background of accumulated experiences, all of which are like little weights thrown into the scale on which his decision is being weighed. Each of them may be small; the question is how they will add up.

AFFIRMATIVE: Somewhere in the back of Sweet's head, these items are adding a little weight to the scale of "presenteeism":

When he first came on the job, Mr. Williams, the foreman,

. . . gave him a lot of personal attention;

. . . was always available when Sweet needed a hand.

In the following months, Williams

. . . helped him make friends with the others on the job;

. . . participated in the casual social life of the work group;

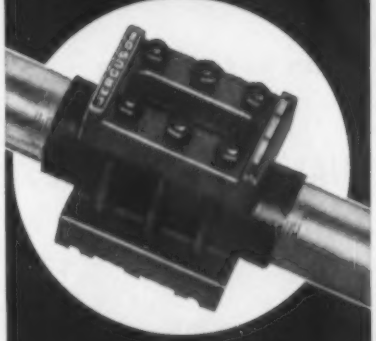
What Do You Know About Absenteeism?

If your top executives can answer the questions below, especially No. 9, chances are, absenteeism in your company is under control.

1. Which day of the week generally shows the highest rate of absence?
2. Which the lowest?
3. Which rate of absenteeism is considered to be "normal"?
4. Is *length* of absence more important than *frequency?*
5. Is sex a factor; that is, do you find a higher or lower absentee ratio among women than men?
6. What is an "excused" absence?
7. Is there a connection between absenteeism, turnover and injury rates?
8. Why can't absenteeism generally be handled by simply cracking down?
9. *Is management itself responsible for absenteeism?*

See Page 352 for answers.

NEW . . .
Jerguson Sight Flow Indicators



easily and inexpensively installed to show movement of liquid in pipe lines

Here is a new line of Sight Flow Indicators . . . easily and inexpensively installed in any new or existing pipe line ½" to 2" N.P.T.

The special design of these new indicators results in a turbulence in the flow of liquid, making it easily visible. Several types of indicating vanes, installed within the chamber, may also be furnished, according to variable conditions of rate of flow and viscosity of liquid. For indication of minute flows, small Sight Flow Indicators with a rotating vertical rising ball are available.

Jerguson Sight Flow Indicators are soundly designed, carefully made, and are backed up by a company with over 40 years experience in the field. Available in Transparent and Reflex types, in a wide variety of materials and linings, and with Wedge Type Illuminators, Haveg Chambers, Non-Frosting Glasses, or other special construction.

If you have a problem of viewing the flow of liquid in a pipe line, it will pay you to investigate the new Jerguson Sight Flow Indicators today. Send us your requirements or write for Data Unit.

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Gages and Valves for the Observation of Liquids and Levels

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- Constant Accuracy
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WRITE FOR BULLETIN 350

PALMER
THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording and Dial Thermometers

Answers to Quiz

(Questions on Page 351)

1. There's more absenteeism on Mondays.

2. Payday.

3. According to the U. S. Department of Labor: "Nobody knows what 'normal' absenteeism is."

Company A feels it's doing fine if the absenteeism rate doesn't go over 5 percent. Company B's executives start having ulcers if the rate pushes 3 percent.

4. Frequency is generally considered a better measure of the problem. One employe, for example, stays out for 20 days because of illness. Another employe stays out ten different times totalling the same 20 days. It's usually easier to adjust to a single absence of long duration.

5. Women present more of an absentee problem. For example, in one departmental study, investigators found that 12.5 percent of the men had one or more absences, against 27.3 percent of women.

6. "Excused absence" covers the cases where an employe's request for permission to stay out has been okayed by the supervisor. There is no single rule for excused absences. Custom varies from company to company.

7. Many companies have found that absenteeism, turnover and injury rates rise and *fall* together.

8. Attempts to decrease absenteeism by stern discipline occasionally have proven effective. However, resultant grievances and generally low morale often became as bad as the original absenteeism.

9. The answer to this question lies at the very heart of the entire absentee problem. The fact is—

. . . poor management, specifically poor supervision, *does cause* absenteeism;

. . . good management, especially good supervision, *causes presenteeism.*

. . . showed consideration for his requests, complaints and suggestions.

And so on. To round out the picture, just add all the items you can think of that make a man feel he's doing a job, not merely holding down a job.

Consider the following three steps in analyzing your company picture and tracing your absenteeism to basic causes:

Brightening the Picture

1. Get the Figures—Calculating the rate of absenteeism is the obvious starting point. The formula to use is—

$$\text{percent of absenteeism} = \frac{\text{man-days lost}}{\text{man-days scheduled}} \times 100$$

Company A has 100 employes, each scheduled for eight hours, 24 days of the month. Checking monthly attendance records shows that 210 man-days were lost.

The total man-days are 100 (number of people scheduled) multiplied by 24 (number of workdays in the month) or 2400. Filling in the formula the final calculation would be—

$$\text{percent of absenteeism} = \frac{210}{2400} \times 100 = 8.75 \text{ percent}$$

Questions that often come up in figuring this frequency rate are:

. . . Should excused absences be included? Yes. If they're not, you don't get a true picture.

. . . How about absence that's un-

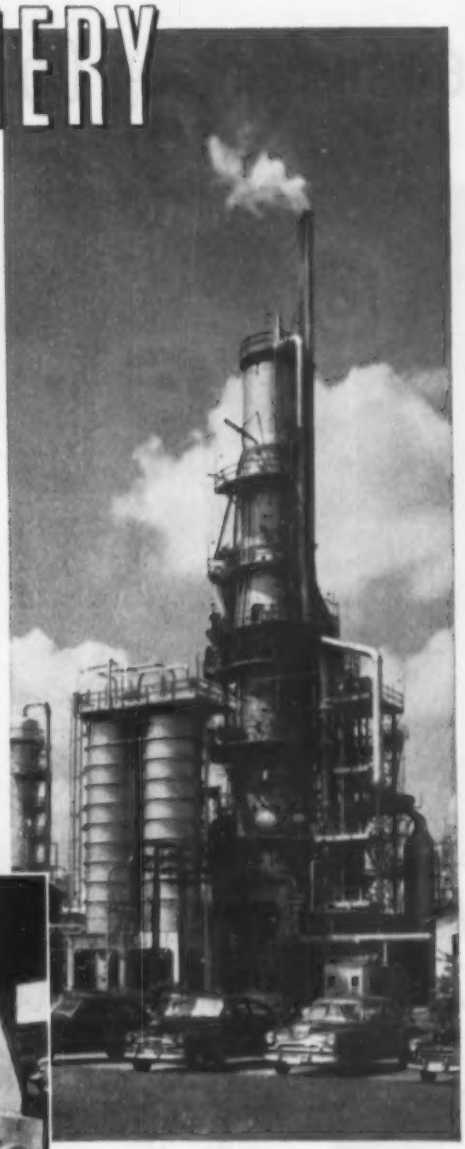
TABLE 1

A	B	C
1 man out 14 days because of serious illness.	6 man-days lost. Employe out because of asthma attack.	5 workers out one day each for "personal business."
	1 man-day lost. Employe had to appear in court.	5 workers out one day each, "headaches," "upset stomaches," etc.
	7 man-days lost. Two working mothers tending to sick children.	4 employes out one day each. Transportation.
14 man-days	14 man-days	14 man-days

MODERN REFINERY EQUIPMENT

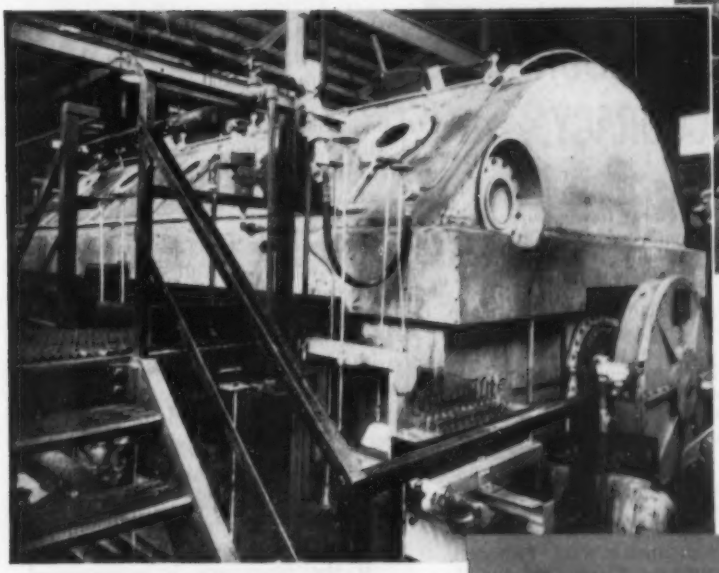
pays dividends . . .

. . . in greater production, higher quality, less maintenance cost and less down time due to failure. CB&I, a pioneer in the manufacture of welded steel plate structures for the petroleum industry, design, engineer, fabricate and erect such structures as Hortonspheres®, Hortonspheroids®, processing towers, and Conkey filters . . . modern refinery structures built to exacting specifications. When you plan welded steel plate structures for your refinery be sure to write our nearest office for information, estimates or quotations.



FLUID CAT CRACKER

CB&I built the reactor-regenerator and catalyst hoppers for the UOP fluid catalyst cracking unit shown above at the Rock Island Refinery Corp., Zionsville, Indiana, refinery.



CONKEY SOLVENT DEWAXING FILTERS

These filters are specifically designed for the clarification filtration of oil solvent mixes for the recovery of slack wax in refinery MEK solvent dewaxing plants. They are also applicable to product wax recovery from recrystallization filtration of slack wax with concurrent removal of product wax and soft waxes from low cold test oils.

CB&I

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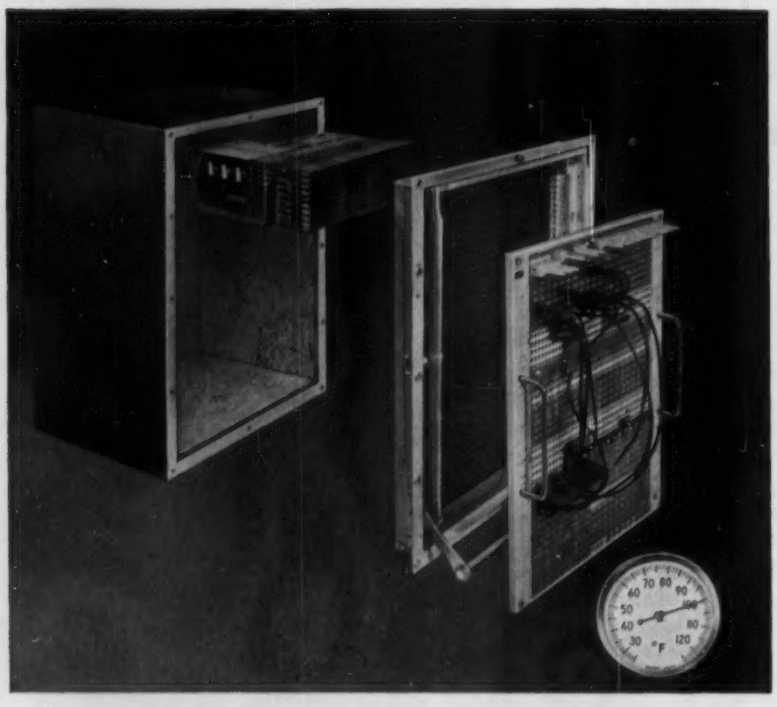
News in Analog Computing...



ASSURES MAINTENANCE OF YOUR EQUIPMENT'S ORIGINAL ACCURACY...

It is of understandable importance to you, when investing in analog computing equipment that you have definite assurance the equipment will maintain its original accuracy in use.

Such assurance is yours, in Electronic Associates' Computer Group Type 16-31R. All critical elements, such as precision computing networks, passive elements and relays are contained in a blower-equipped, thermostatically controlled oven located directly behind the patch bay – with temperature controlled to 100° F plus or minus one degree – assuring maintenance of accuracy and stability.

This 16-31R is the Computer which can be expanded by a unique building block system to the most complex systems. Demonstration and rental of computing time is available at EAI Computation Center, Princeton, New Jersey. Details on request. Write Dept. PR 11, Electronic Associates Inc., Long Branch, New Jersey.

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LONG BRANCH, NEW JERSEY

avoidable because of serious illness, etc.? That should also be included. The U. S. Bureau of Labor defines absenteeism as "the failure of workers to report on the job when they are scheduled to work—that is, when they are actually 'on the payroll.'"

2. Evaluate the Figures—In some cases, an absentee rate of 10 percent may be okay. In others, five percent would call for immediate action. Take the three different departments shown in Table 1. Each has the same number of employes, and the same number of man-days scheduled.

• Note that although all show the same number of days lost, it's Department C that needs special action.

3. Spotlight the Bad Actors—Absenteeism is usually confined to a small percentage of employes. By using the absentee frequency rate, you can spot them.

Here's how it would work on a departmental basis. Here's a typical list:

Name	Days absent for month of.....
Tom	0
Bill	0
Harry	1
John	5

By simply glancing down this list, you can spot the absentee troublemakers. But be sure not to assume that these individuals are staying out wilfully. They have problems that are keeping them out. The question is how to tackle these problems.

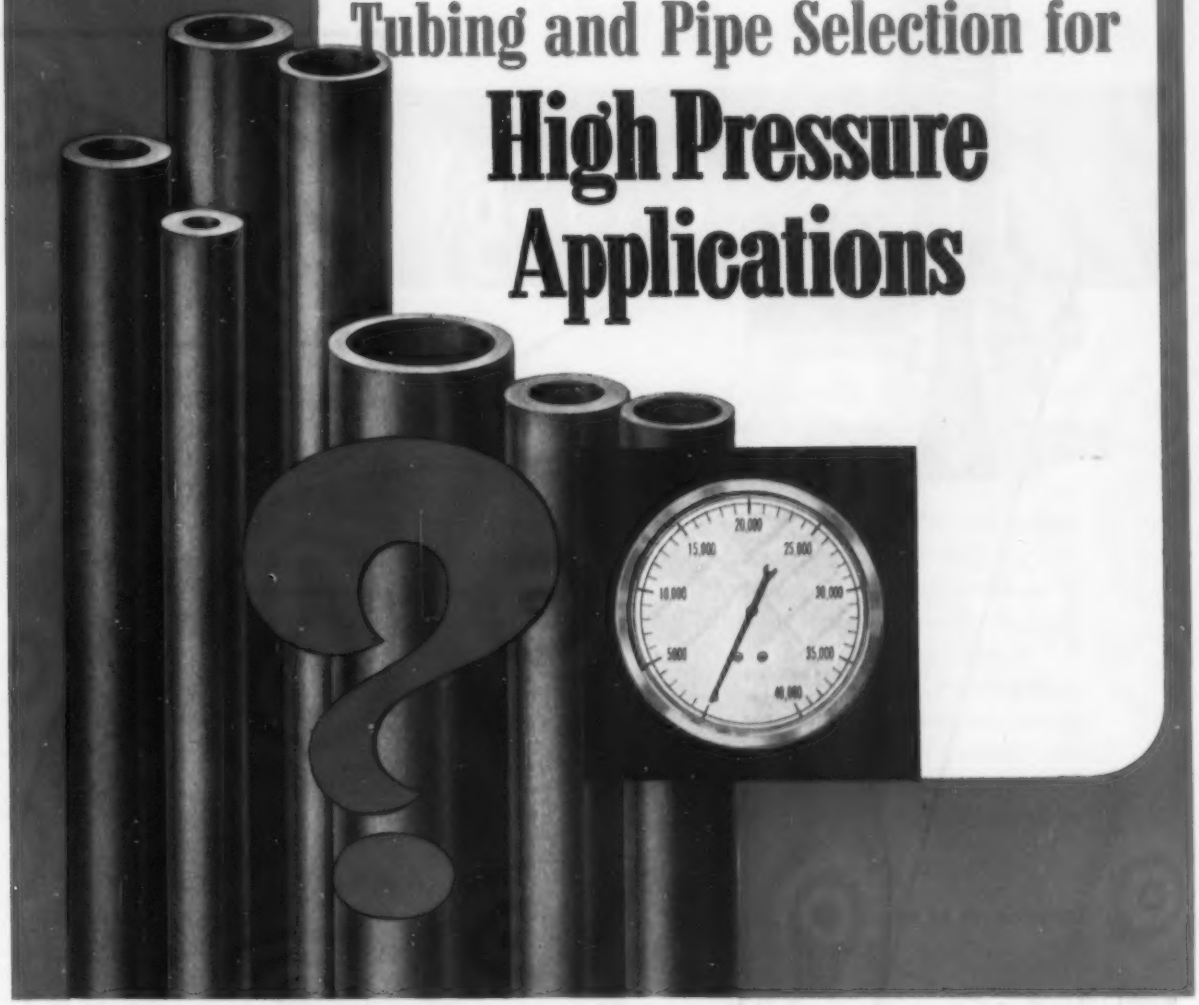
Handling the Absentee—Once you've drawn a bead on the individuals causing your absenteeism, you're in a position to apply additional remedies. You have to work more closely with them, to solve what's essentially a mutual problem.

It's a good practice to have a returning employe see his supervisor before starting work. Whether the interview lasts for one minute or 30, the first objective is to establish the *reason for the absence.*

If the supervisor is unconcerned, the employe will adopt a "what's-the-difference" attitude. Regardless of the reason for the absence, you want the employe to know he was missed. Then, if he was away for good reason, he'll be pleased to know he's important to the work. If his reasons aren't quite good enough, he'll recognize the implied rebuke.

As one supervisor put it: "By mak-

Tubing and Pipe Selection for High Pressure Applications



Specific working pressure is one of the major considerations in the choice of tubing or pipe for a given fluid-handling application. To obtain optimum efficiency and economy, however, it is necessary to consider temperature conditions, tube size, mechanical strength of the steel, and corrosion hazards.

A case in point that clearly shows the complexity of selecting the right tubing for pressure applications involved the installation of a stabilized stainless steel to carry methanol and unreacted synthesis gases at 300 F and 5000 psi while being exposed to chloride-bearing bayou water. This exposure caused pitting corrosion which, in turn, localized the pressure stresses at the roots of the pits causing, eventually, failure by stress corrosion. To effectively solve this costly problem, B&W with its long experience in all phases of tubing applications, helped in selection of B&W Croloy 5. This choice provided increased resistance to the pitting while meeting the temperature and pressure factors satisfactorily *and at a substantial savings in material cost.*

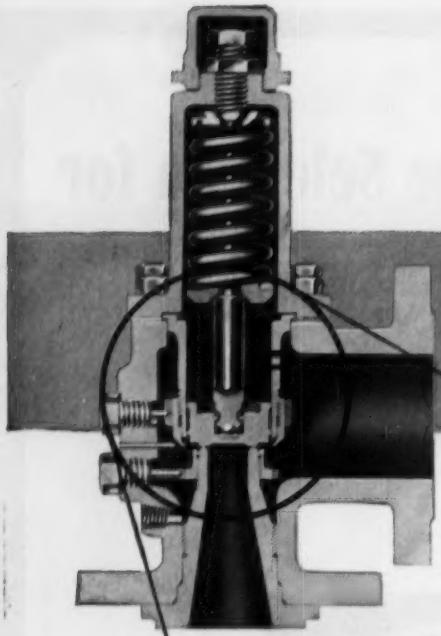
It takes an expert to specify the optimum tubing or pipe for any particular application. And there is no substitute for the kind of experience with such problems that you will find at B&W. To get the most benefit from B&W's long experience in matching tubes and piping to jobs—call on Mr. Tubes, your nearby B&W Tube Representative. *Or write for Bulletin 6.*

B&W
TUBULAR PRODUCTS DIVISION

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
General Offices: Beaver Falls, Pennsylvania
Plants and Products
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing
Milwaukee, Wis.—Seamless Tubing; Welded Stainless Steel Tubing; Seamless Welding Fittings

TA-5058-P

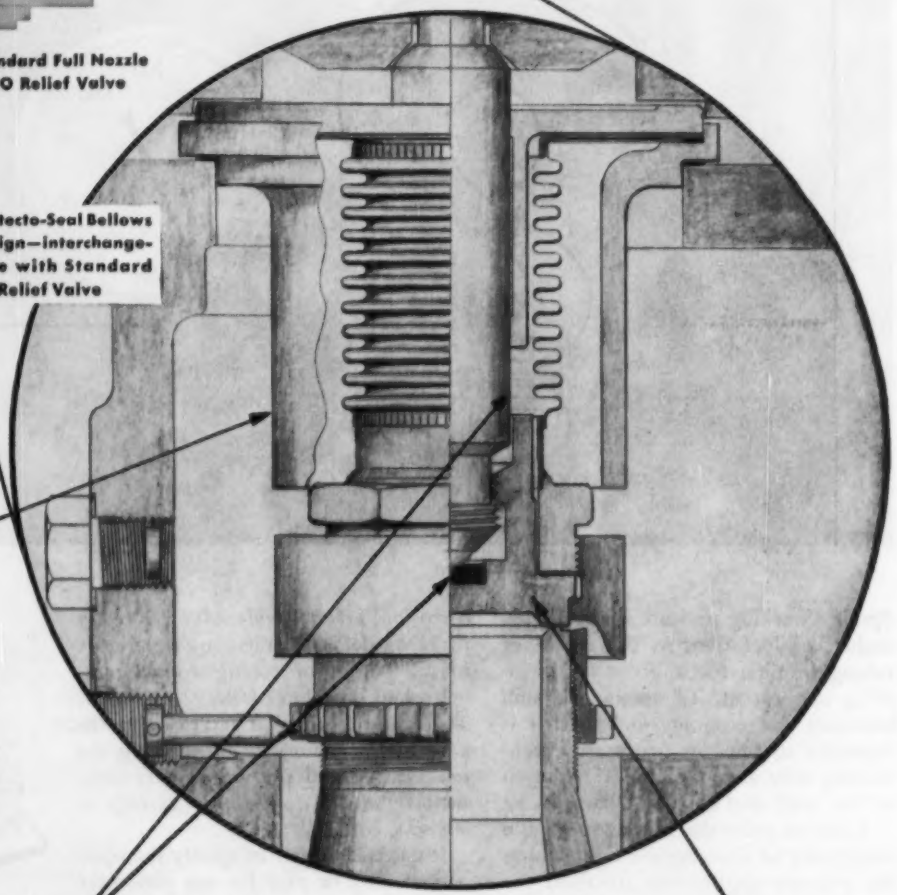
For more data on advertised products, use Readers' Service Cards, last page.



CROSBY Protecto

Standard Full Nozzle JO Relief Valve

Protecto-Seal Bellows Design—Interchangeable with Standard JO Relief Valve



EXCLUSIVE

BELLOWS PROTECTOR
(Pat. Applied for)

1. *Isolates and protects Bellows from turbulence caused by flowing media—reducing tendency of Bellows to fatigue.*
2. *Acts as positive lift-stop thereby preventing over compression of the Bellows.*

EXCLUSIVE

1. All moving parts are guided and held in perfect alignment from a single member.
2. The floating disc is loaded at the lowest point possible in the disc to provide the best in alignment stability and seat tightness.

FLOATING DISC

1. Simplifies maintenance.
2. Ease of dis-assembly.
3. Permits remachining.
4. Anti-fouling.

Seal Bellows Relief Valve

The addition of the Crosby Protecto-Seal Relief Valve to the well known line of Crosby JO Relief Valves marks a forward step in the design and construction of valves primarily for use on services where protection against corrosion, fouling of working parts, and low back pressure surges is required. The design represents the results of field tests conducted under the severest operating conditions.

The design of the valve is featured by the EXCLUSIVE Bellows Protector which shields the Bellows from adverse turbulent effects from the flowing media, preventing premature failure of the Bellows due to fatigue. The two ply bellows is so designed that the effective area of the valve seating surface is essentially balanced to nullify the effect of variable and constant back pressure on the performance of the valve. Now, with the Protecto-Seal Valve and the Balanced Area Piston Type Valve, Crosby offers relief valves for the widest range of back pressure conditions.

The Protecto-Seal construction is available in eleven orifice sizes and is interchangeable with the present line of Full Nozzle JO Relief Valves. Pressure-temperature scopes and dimensions remain the same as listed in the present 300 Catalogue. Valves available with internal heating coils and flushing nozzles on request.

Send operating data to Wrentham for recommendations.

Proven Performance

Designed, tested, and proved in our own steam and water test laboratories over a wide range of pressures. Performance checked on:

GAS—A.S.M.E. Test Facility
VAPORS—Wide range of temperature and Pressure
LIQUIDS and FLASHING FLUIDS—Private Laboratories and Power Plants of a leading Public Utility

This Valve has been tested for performance and flow at pressures from 25 p.s.i. to 2500 p.s.i.

CROSBY STEAM GAGE & VALVE COMPANY

FACTORY: WRENTHAM, MASSACHUSETTS

BOSTON • NEW YORK • CHICAGO • DALLAS • LOS ANGELES • LONDON • PARIS

For more data on advertised products, use Readers' Service Cards, last page.

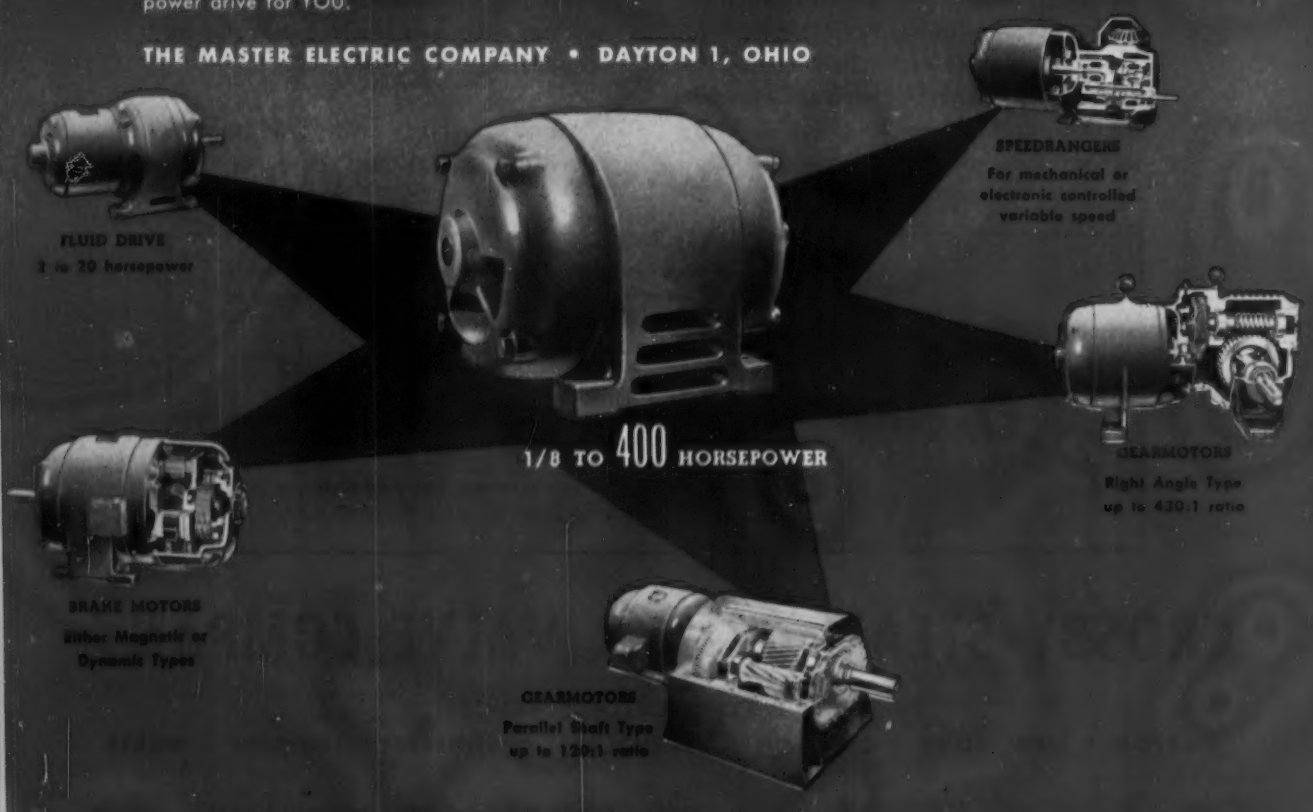
Whenever you select a power unit, don't put a straight-jacket on your ideas . . . consider ALL of the possibilities of modern power drives.

For example consider the many useful combinations that can be secured with the basic Master power units shown below. They're designed so they can be easily combined together to give you the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features in one compact unit that you can use RIGHT where you want it. Nowhere else will you find power units that are so flexible, so easily adaptable, and in such a wide range of types and ratings.

Master power drives are available in thousands and thousands of ratings (⅛ to 400 HP) . . . in open, enclosed, splash proof, fan cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 430 to 1 ratio . . . with electric brakes . . . with fluid-drive . . . with mechanical or electronic variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best power drive for YOU.

give your brains a chance

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



ing a point to talk to every returning absentee, I make it clear that I know they've been out. And one employe who used to have a bad attendance record told me the other day, 'You made me run out of excuses.'"

Attacking the Cause—(a) The condition. Let's say, for example, a worker says he's been forced to stay away because of bad weather and overloaded local transportation facilities. You may be able to suggest other ways of making the trip. This is especially true of new employes who aren't familiar with the neighborhood.

(b) The work schedule. You may want to consider changing an employe's hours if an outside situation makes it difficult for him to report in with the others.

(c) The job. In cases where a specific on-the-job condition is at the bottom of the absence, you may be able to remove the obstacle either by re-assignment or by modifying the work itself.

(d) The employe's attitude. You may decide on the basis of your investigation that the cause was not so much any one single factor but the employe's attitude. Frequently, for example, in the case of the transportation hardship, pointing out that other employes have similar—and even worse—problems may help to influence him.

Consider action in the extreme cases. The employe who poses a continual attendance problem may finally have to be disciplined. What you finally decide should grow out of the facts of the case. Don't "make examples."

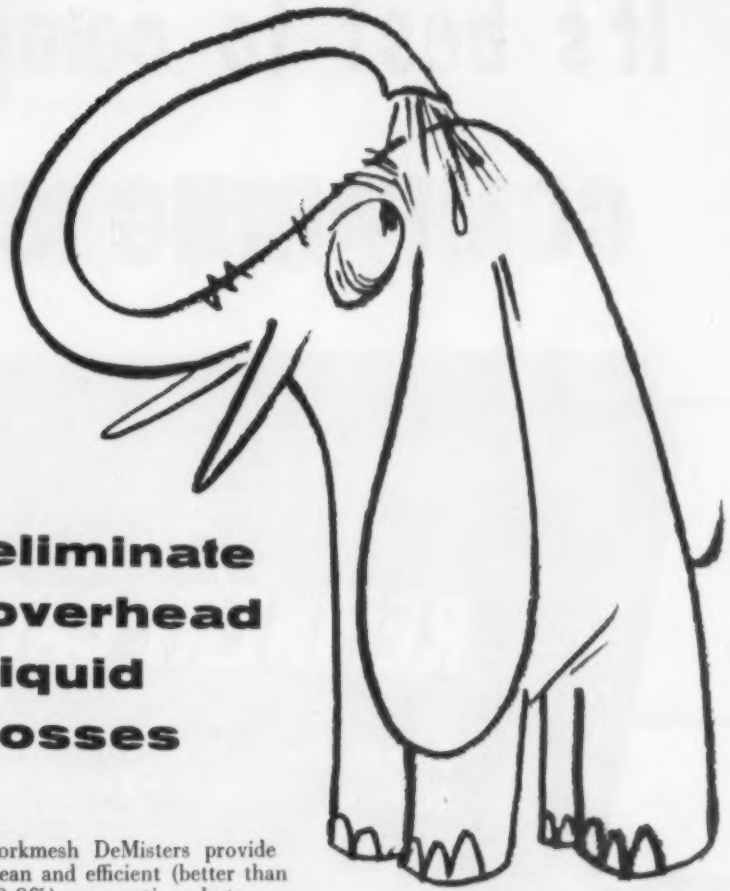
You may simply have to get tough and choose between further efforts to straighten him out and firing him.

In a period of general labor scarcity it's logical to prolong the straightening-out effort. Four days work out of five is better than none. But watch out: one man's poor attendance may infect others with absenteeism.

The Cost Factor—It's sometimes cheaper to put up with the absenteeism than to remove the cause. It's not a happy decision—but there may be no choice. Take the case of the company that suffered high absentee rates in bad weather. Lack of near-by parking space meant that employes had to walk five blocks through snow and cold.

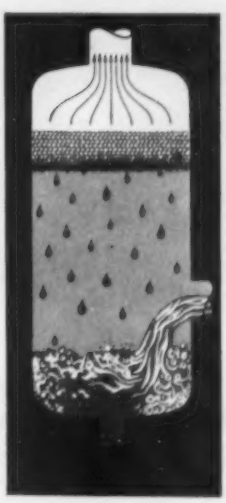
Build a parking lot? The costs were simply too high.

In many cases, though, specific moves on your part can and will make a substantial difference. ##



eliminate overhead liquid losses

Yorkmesh DeMisters provide clean and efficient (better than 99.9%) separation between liquid and vapor with virtually no pressure drop. Easily installed into new or existing equipment, York wiremesh DeMister pads provide the most effective means for recovering valuable liquids entrained in gases or vapors, and by permitting operation at higher than normal velocities, leads to increased production from existing equipment. The unique operating principle, shown below, involves miles of wire knitted into a mesh pad that lets clean vapor through, but knocks out entrained liquid and tosses it back. In one instance, a scrubbed gas stream at 475 psig carried off 0.5 to 1.5 lbs. of triethylene glycol per MMCF even after passage through a vane type mist extractor. Because of inadequate liquid recovery, the vane type extractor was replaced by a stainless steel Yorkmesh DeMister at a total cost of $317.00, resulting in a recovery of 4.9 gallons of triethylene glycol per day, which amortized the entire DeMister pad installation in 29 days. It will pay you to investigate the advantages that Yorkmesh DeMisters can bring. Write for Bulletin 17 which will put further facts at your fingertips.



POSITIVE SEPARATION MEANS NO OVERHEAD LIQUID LOSS

Liquid droplets entrained in the vapor stream impinge on the extensive wire mesh surfaces. The fine droplets coalesce, the liquids drain free and clean vapor passes overhead.

Yorkmesh Demisters provide clean separation between liquid and vapor in: Vacuum towers • Distillation Equipment • Gas Absorbers • Scrubbers • Evaporators Knock-Out Drums • Steam Drums

YORK

OTTO H. YORK CO. INC.
6 CENTRAL AVENUE, WEST ORANGE, N. J.

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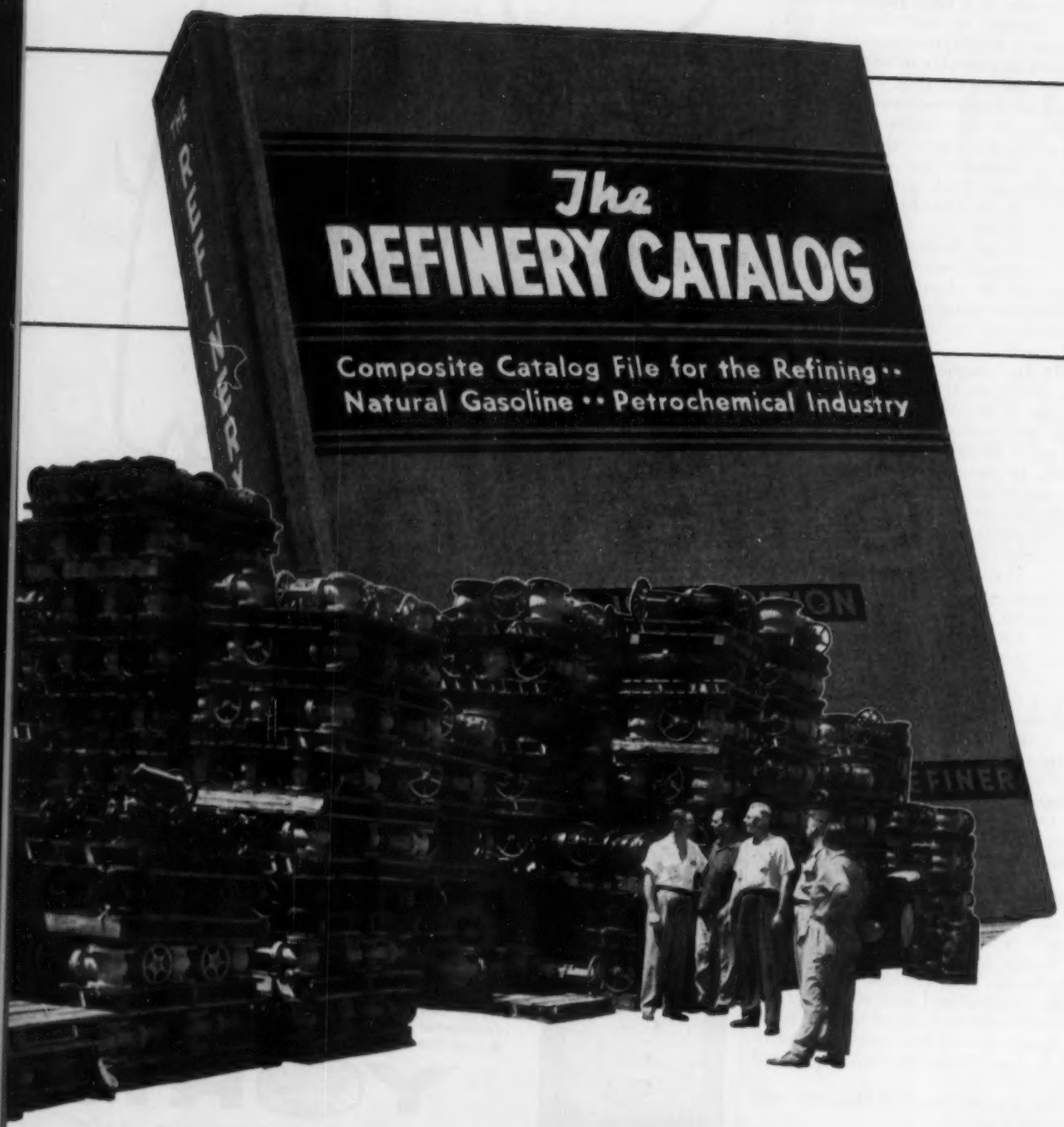
It's best to compare before

COMPARING IS EASIER IN



you buy valves...

THE REFINERY CATALOG

In the pages of the REFINERY CATALOG you will find

the complete or condensed catalogs of 46 of the leading manufacturers of valves. There are 51 pages of valve specifications and other data in the current catalog.

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Alloy Steel Products Co., Inc.
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Cochrane Corp.
The Continental Supply Co.
Corning Glass Works
Crosby Steam Gage & Valves Co.
Davis Regulator Co.
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Everlasting Valve Co.
Farris Engineering Co.
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Hamer Oil Tool Co.
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Marsh Instrument Co.
Martin-Decker Corp.
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National Carbon Co., A Division of Union Carbide and Carbon Corp.
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Orbit Valve Co.
Pacific Valves, Inc.
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R-P&C Valve Division American Chain & Cable Co., Inc.
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Strahman Valves, Inc. Klingerit Inc. Division
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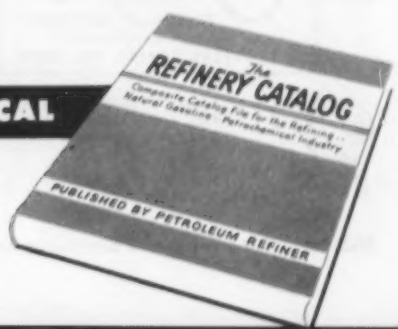
When you're comparing valves or any other item of refinery equipment, you'll find them easier and quicker in the REFINERY CATALOG. REFINERY CATALOG provides you with the catalog data you need to compare the lines of the best recognized manufacturers. It contains data on more than 2,500 types of refining, natural gasoline and petrochemical plant equipment.

Almost 300 manufacturers distribute their catalogs in the REFINERY CATALOG, which is completely indexed and cross-indexed for easy usage. REFINERY CATALOG is the only composite catalog issued solely for the refining industry. It is by far your most complete and most convenient source of information on refining equipment and materials.

When you compare or specify refinery, natural gasoline or petrochemical equipment, remember . . . it's easier to look it up in the REFINERY CATALOG.

REFINING • NATURAL GASOLINE • PETROCHEMICAL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TUBING
UP TO
58 FEET LONG
FOR
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Now you can get STRAIGHT lengths up to 58 feet long...at Pacific Tube

Pacific Tube Company has added new pickling facilities, new hydrostatic testing equipment...with the longest draw bench in the west to quantity-produce for you, straight lengths of Seamless Tubing up to 58 feet long. Pacific Seamless Steel Tubing is "Quality Controlled" to insure workability, accurate bending, flarability and long life. It is precision drawn to meet critical specifications and tolerances.

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"Steel Tubes for Industry"
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As Management Sees It . . .

Microfilm Has Its Advantages

(Continued from Page 118)

order, only a few seconds will be required to turn the pages for each exposure. If the data are of various sizes, the collector may have to adjust and re-focus the camera after each exposure. That, of course, may require several minutes, just as the procedure of setting up the camera and changing film after each 36 exposures.

One example of the speed available through this operation: Thirty 11-by-17-inch pages of bound production data were recently microfilmed in ten minutes—from beginning to end.

Use of data—After the data have been collected on rolls of film, they may be utilized by one of several methods:

- If re-tabulation or partial abstracting is necessary, the film may be read with a microfilm reader, a viewer or magnifying glass.
- If portions of the data are to be used frequently, an enlarged positive print may be made.
- If a number of copies of a part of the data are required, an enlarged film positive of the print may be made and Ozalid copies printed from this positive.

Storage and retrieval—Microfilm's usefulness as a depository for large amounts of information presents a problem—how to retrieve any particular variety of data from the files. At least two methods which are satisfactorily in use are:

- If the microfilm collection is small, it is convenient to file both microfilm and paper photographic prints under the names of oil fields, the films being stored in card file drawers in small labeled metal containers.
- If the film collection is large a subject index with numerous cross entries makes it much easier to locate information. Mechanically sorted punched card indexes take up less file space and save time and labor, provided a simple coding system is used. One of the simplest methods involves the notching of all entries in four alphabet scales as four-letter abbreviations. Certain drawbacks of superimposed alphabetical abbreviation codes are eliminated by a new coding method, based upon the fact that the letters of English words occur in the following order of frequency:

E T A O N R I S H D L F C M U Y P
G W B V K X J Q Z

An index entry is reduced to four letters by beginning with the second letter of the expression and removing all E's, then T's, A's, etc., according to this frequency order, until only four letters remain. These four letters are used infrequently in English words. Therefore, they are characteristic of the particular expression.

Following is a group of extremely similar entries and their abbreviations:

Production, gas	pucg
Production, oil	pucl
Production, water	pucw
Productivity index	pvyx
Producing gas-oil ratio	pngg

The initial letter is retained to simplify the sorting of cards into aplhabetical order, if that should become necessary. The system does not produce very good separation of almost identical entries, as indicated above. However, good separation is obtained with most entries, and a good scattering of the punching pattern results.

No code book, classification system or complicated rules of abbreviation are required. The system is not perfect. But it is simple and workable.

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TABLE 1

35 mm FILM	Resolution Lines/mm	Quality of Copy	Cost $/double Frame Exposure	Exposure Time f8 and Office Lighting (in seconds)
Microfilm	175	Excellent	0.007+	2.0
Fine grain film positive	120	Very Good	.004—	8.0
Superior No. 2	80	Good	.008+	1.0
Plus X	95	Good	.008+	0.7

For more data on advertised products, use Readers' Service Cards, last page.

You can do it CHEAPER with UTILITY Electric Power

Another Field Processing Plant completely powered with dependable Utility Electric Power

because Electric Power is flexible . . . compact . . . dependable . . . safe . . . clean . . . and can be installed at a Low Capital Investment, with LOW COST operational advantages, plus many other money saving features, including convenient automatic control.

Petroleum Electric Power Association

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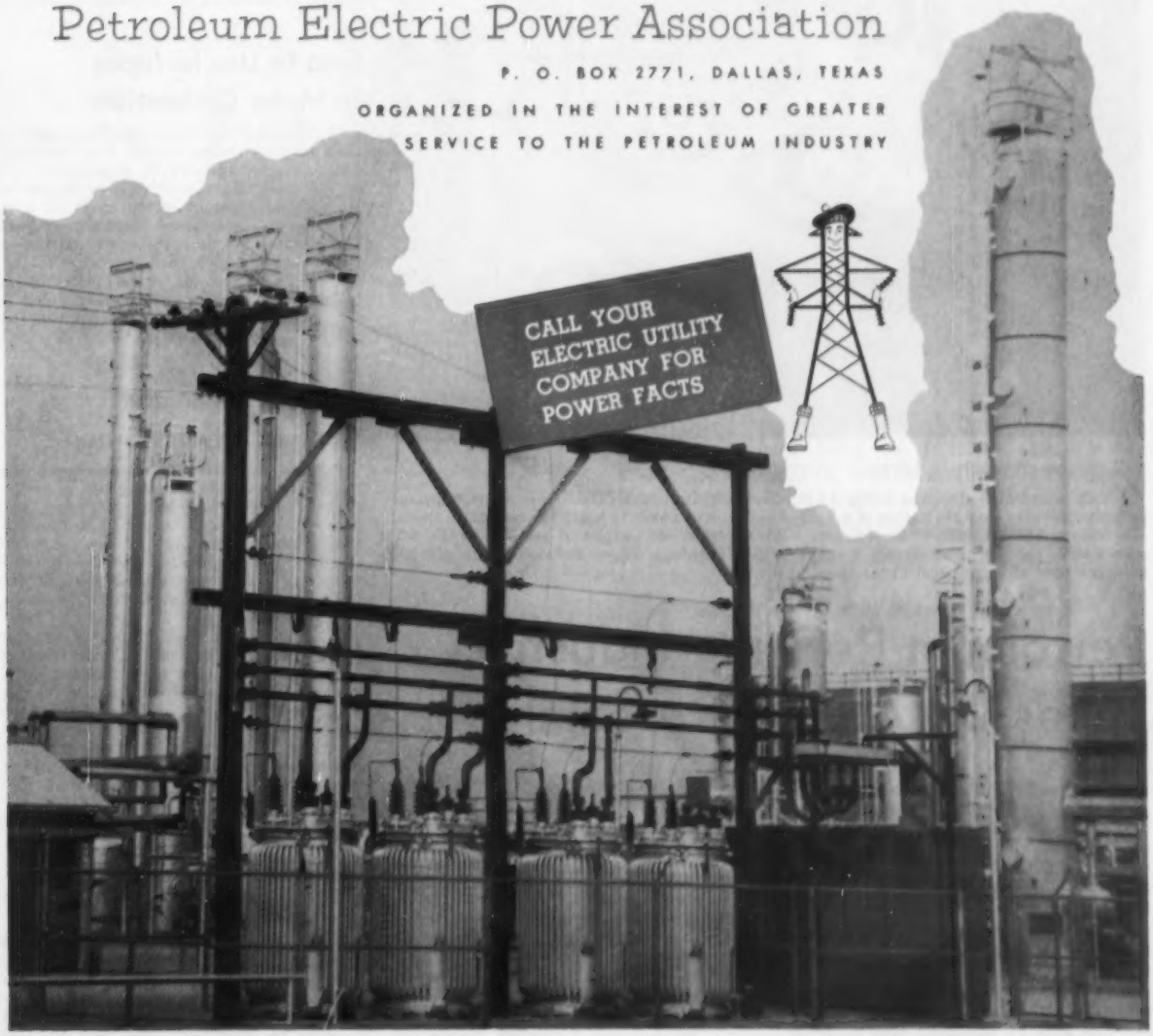
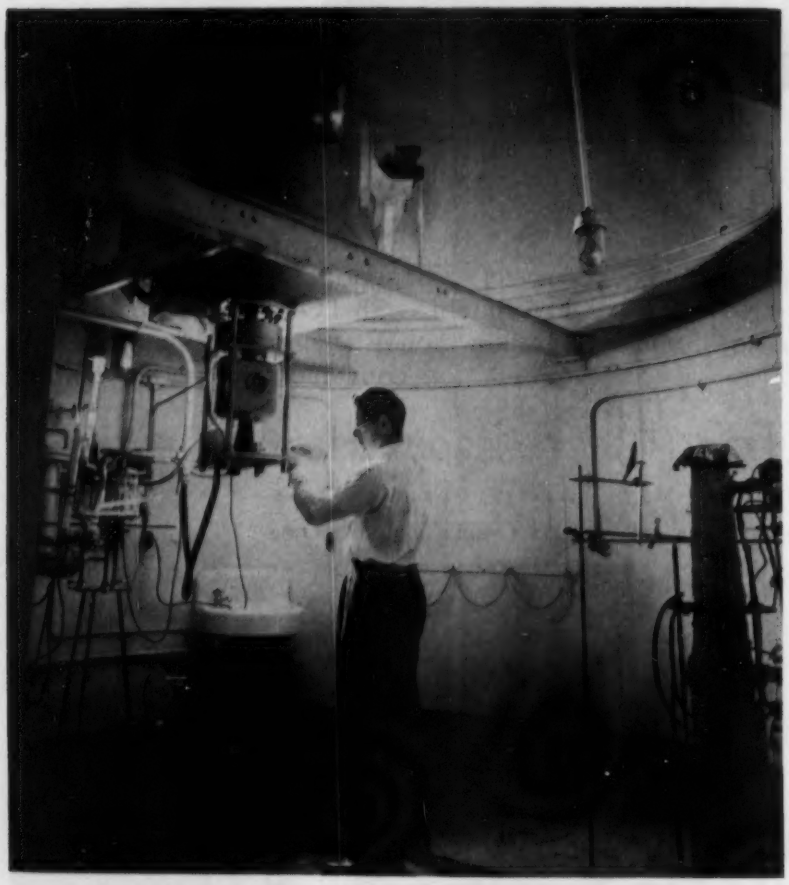
ORGANIZED IN THE INTEREST OF GREATER SERVICE TO THE PETROLEUM INDUSTRY



What's Happening . . .

. . . in the Industry



Speeds Hit 600 Million MPH—

The electron gun in operation at The Atlantic Refining Company's Philadelphia research laboratories is suspended from the ceiling of a pollbox-like structure built to house the company's atomic experiments. The one-million-volt unit fires electrons down into samples at speeds reaching 600 million miles per hour. This velocity is equal to 167,000 miles a second and comes within 20,000 miles a second of being equal to the speed of light.

Petroleum Refining Industry Takes Up Atomic Research

A three-million-volt particle accelerator —the most powerful radiation source available to industry—has been purchased for the Emeryville, Calif., research laboratory of Shell Development Company. And on the other coast, The Atlantic Refining Company is already studying the feasibility of using an atomic accelerator—or "electron gun"—in petroleum processing.

The new device in operation at Atlantic's Philadelphia research laboratory since April 1955 is used to speed atomic particles through magnetic coils to reach velocities up to 600 million m.p.h. or more as they are shot into petroleum hydrocarbons. Built by General Electric Company, the $75,000 unit operates at one million electron volts and this output can be tripled and may possibly be raised as high as ten million volts.

The Emeryville unit, a Van de Graaff accelerator, will be the first of its size in the petroleum industry. It is being built by High Voltage Engineering Corporation and will be installed in June 1956.

Up to now petroleum processing has

Continued on Page 366

Improved Spectrometer Used in Shell Refinery

Shell Oil Company has put into operation at its Houston refinery a new electronic device—a special development of the mass spectrometer—which will identify two to three times as many chemical compounds in petroleum as is possible with conventional mass spectrometers.

Company scientists believe knowledge gained from the use of electronics in this matter will lead to improved quality and an increase in the quantity of product output.

Design and manufacture of the instrument was handled by Consolidated Engineering Corporation. The firm spent a year testing the spectrometer which was developed in conjunction with Shell's research scientists at the Houston refinery.

Esso to Use Isotopes In Meter Calibration

A radioactive isotope solution will be used on two meters at the Esso Standard Oil Company refinery in Bayonne, N. J., to make a calibration check to determine which meters should be replaced.

The two boiler-house meters have been confounding engineers by measuring a steam output higher than the water intake. Either the water or steam meter is at fault, but conventional tests have failed to reveal which of the units should be replaced.

Sun Oil Organizes Applied Physics Group

Advancements in petroleum-refining technology and the growing use of radioactive tracers, electronic computers and data-logging devices have lead to Sun Oil Company's organizing a new Applied Physics section. Headed by Dr. E. Neil Shawhan, the new group is part of the Engineering division of the Manufacturing department.

It will work on a wide range of projects for the department, and a by-product of its operations will be the development of new instruments and devices. A major portion of its work will be devoted to improvements in the efficiency of refining processes. The section, headquartered at Newtown Square, Pa., also will be available to handle special problems for other departments.

Canadian Refinery Plans Automation Equipment

An automatic recording unit, described as the biggest single step towards complete automation in the process industry, has been contracted for the new 20,000-barrel-a-day refinery Canadian Petrofina, Ltd., is building in Montreal. The new $50,000

THE BIG 4 ...in High Pressure-High Temperature TAPPING MACHINES

LARGE GULF COAST REFINERY MAKES 20" TAP INTO 24" STEAM LINE AT 600°F. AND 200 PSI PRESSURE . . . WITHOUT SHUTDOWN.

WmSON - HILLCO MODEL 1200 TAPPING MACHINE

PRESSURES TO 1200 PSI @ 100° F.

TEMPERATURES TO 700° F. @ 700 PSI

TAPS 12" to 24"

MODEL 660
TAPS 3" TO 14"

MODEL 300
TAPS 4" & SMALLER

MODEL 100
TAPS 2" & SMALLER

MANY REFINERIES SUCH AS THE ONE SHOWN ABOVE HAVE PROVED WmSON-HILLCO TAPPING MACHINES FOR MAKING CONNECTIONS TO:

- HIGH TEMPERATURE STEAM LINES
- HIGH PRESSURE GASOLINE AND UTILITY LINES
- CEMENT LINED AND TRANSITE PIPE
- PRESSURE VESSELS

Rental-purchase option applicable to models 1200 and 660.

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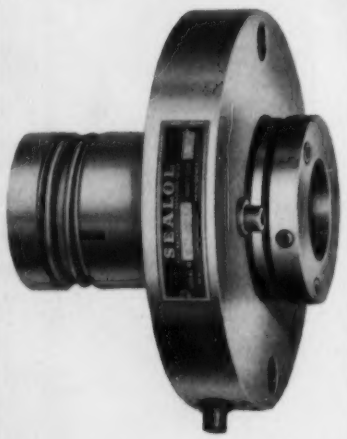
For more data on advertised products, use Readers' Service Cards, last page.

HOT NEWS

FOR HOT PUMP USERS...

Field proven in high temperature refinery process pumps, the Sealol HT Mechanical Pump Seal ends expensive, dangerous stuffing box leakage. A cartridge-type seal, it is furnished ready to install, requiring no special machining or assembly of loose parts. Because of its all-metal construction, this seal needs no external cooling circuit, yet it provides positive sealing of hot oil, hot bottoms, and other high viscosity products at temperatures up to 800°F.

Low on initial cost . . . low on maintenance . . . the Sealol HT Mechanical Pump Seal is the economical way to seal your high temperature process pumps. Send today for Bulletin 11, or submit your sealing problem for engineering recommendations.



The new Sealol "HT" Mechanical Seal for high temperature refinery pump service

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SEALOL

THE BALANCED PRESSURE SEAL

What's Happening. . .

unit, called an electric logger, is scheduled for operation in November.

It will monitor, analyze and record a total of 480 process variables in the nine production units at Petrofina's new plant. Under normal conditions, the unit will automatically type out the value of variables each hour. It will report selected or abnormal conditions between logging intervals.

In case of trouble, the unit will signal an alarm and immediately type the abnormal condition and its location.

Petroleum Refining Industry Takes Up Atomic Research

Continued from Page 364

relied on heat to break and reform gasoline molecules into more powerful fuels. This method shatters molecules haphazardly, causing many fragments to be lost. With atomic radiation, petroleum scientists hope to snip the molecule into the exact pieces desired. Dr. Vincent J. Keenan, of Atlantic's Research and Development department, has compared conventional refining methods to "slicing balony with an axe."

Two other companies actively studying atomic radiation possibilities in refining are Socony Mobil Oil Company, Inc., and Esso Research and Engineering Company. Still another refining company, The Standard Oil Company (Ohio), has been granted an access permit to restricted Atomic Energy Commission data, in line with the government's program to encourage industry's participation in the development of atomic energy for peaceful purposes.

Instead of an electron gun, radioactive cobalt is being used at the Esso Research Center in Linden, N. J. The material is serving as the source of powerful gamma rays which the company hopes to employ in refining (**Petroleum REFINER, December 1954, page 220, and August 1955, page 128**). Socony Mobil, however, plans to use both techniques. In addition to an atomic accelerator, the company will use fission-waste radio-isotopes and secondary radioactive elements.

To Use Both Techniques

Socony Mobil, however, plans to use both techniques. In addition to using an atomic accelerator, it will employ fission-waste radio-isotopes and secondary radioactive elements in its research program.

The company will join eight other companies from outside the petroleum industry in building a nuclear reactor, and establish a nuclear research center of its own to be operated as part of the Socony Mobil research system. The company's own facilities will include a Van de Graaff accelerator and associated facilities providing high-energy electrons, protons, X-rays and neutrons for research in nuclear physics and radiation chemistry; laboratories equipped for manipulation of fission-waste radioisotopes as well as secondary radioactive sources which will be activated by irradiation in the reactor, and facilities for assaying radioactive materials.

Advantages of Accelerator

Shell scientists will use the Emeryville accelerator in studying the effects of radiation on fuels, lubricants, plastics and other oil-derived products. With its powerful beam of electrons, the company hopes to learn more about changes that take place in matter exposed to radiation. At-

For more data on advertised products, use Readers' Service Cards, last page.

Groceries . . . miracle of BRICK

Colorful cans, gleaming bottles, eye-catching cartons riding in the cart—not a single one of them would be there were it not for refractory brick. Brick that makes steel. Brick that makes glass. Brick that makes paper.

Everything that's made and everything that's moved starts with refractory brick in one form or another, lining the furnaces of industry. The requirements are almost infinite in variety.

To provide the truly complete refractory service that industry needs, General Refractories employs the world's largest refractories research laboratory; brings materials across oceans; manufactures in plants strategically located to serve industry swiftly . . . dependably . . . economically . . . everywhere.

GENERAL REFRACTORIES COMPANY, Philadelphia 2

GENERAL REFRACTORIES

COMPLETE REFRACTORIES SERVICE

FOR THE GLASS INDUSTRY . . .

RITEX—Unburned basic brick—in magnesite, magnesite-chrome, and chrome-magnesite. More resistant to spalling. Lower porosity, lower thermal conductivity—high hot strength.

GREFCO SILICA BRICK are available at convenient locations from California to Pennsylvania. Glass men know there is no finer product. No more dependable supply.

OLIVE HILL—An exceptionally strong and dense fireclay brick—true to size and shape.

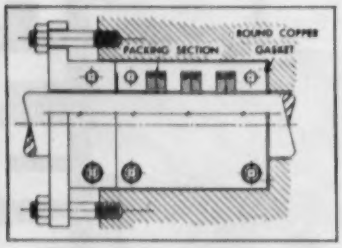
Left: Reciprocating air compressor

Below: Garlock 809 Floating Metal Packing split-case design

For air compressors, users report

GARLOCK SPLIT-CASE METAL PACKINGS

have 2 big advantages



1. **LONG, TROUBLE-FREE LIFE.** Minimum of 7 years with proper lubrication.

2. **CAN BE INSTALLED *WITHOUT* DISCONNECTING THE ROD.** Downtime is reduced to a minimum.

You can eliminate the cost of frequent packing replacements and unnecessary downtime by installing Garlock split-case metal packings on your reciprocating air compressors. Service reports show that these Garlock metal packings have given 15 years and more of trouble free service with a minimum of rod wear.

For complete information, call your Garlock representative or write today for Brochure 3889.

THE GARLOCK PACKING COMPANY, PALMYRA, N. Y.

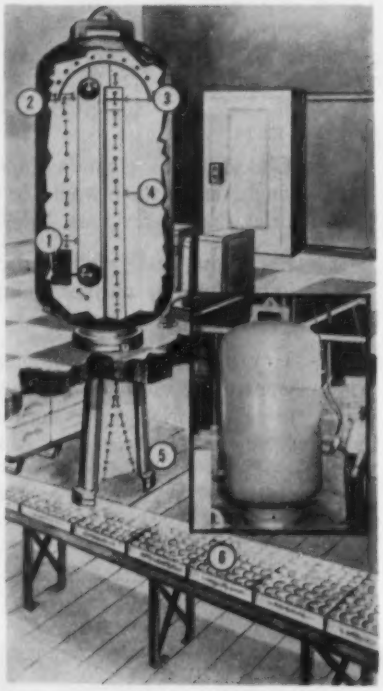
Sales Offices and Warehouses: Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Los Angeles, New Orleans, New York City, Palmyra (N.Y.), Philadelphia, Pittsburgh, Portland (Ore.), Salt Lake City, San Francisco, St. Louis, Seattle, Spokane, Tulsa

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK

PACKINGS, GASKETS, OIL SEALS,
MECHANICAL SEALS, RUBBER EXPANSION JOINTS

What's Happening. . .



To Require Two Stories—

A two-story arrangement will be needed for the three-million-volt atom smasher when it is installed in Shell Development Company's Emeryville, Calif., laboratory in June, 1956. The voltage generating column, which produces a high-intensity beam of electrons, will be on the upper floor, and material being exposed to radiation will be passed through the beam on the floor below.

The photo inset shows the actual housing for the voltage generating column, and the diagram explains how it works. An electric charge sprayed on a fast-moving belt (1) is carried to the top of the column and transferred to a terminal (2), resulting in a great voltage difference between the upper and lower ends of the machine. Charged particles leave the terminal through a heated cathode (3) and hurtle downward along the only possible escape route, the high vacuum tube (4), where they are accelerated to almost the speed of light. A funnel-like attachment (5) directs the particles precisely on to material being irradiated, which is passed through the beam on a conveyor belt (6).

lantic already has made hydrazine by bombarding ammonia with atomic radiation. The company's yield of hydrazine, however, is still too low to be profitable.

Another accelerator, a two-million-volt machine, is in operation at Shell's research facilities in Houston. Installed in September 1954, the unit is used in studies to help tell the age of rock formations.

The Van de Graaff unit is believed by Shell scientists to have two advantages over radioactive sources for industrial use. First, when turned off it presents no radiation hazard, and second, the accelerator is easily adapted to continuous production techniques such as conveyor-belt treatment systems.

The unit in operation at Philadelphia fires a stream of atomic particles that are tightly focused on a petroleum sample. The energy output of the gun is flexible

For more data on advertised products, use Readers' Service Cards, last page.

A Good Turn For Motorists

Most people consider a car the second-biggest purchase they'll ever make. Anything that extends its life or improves performance naturally contributes to your pocketbook as well as your motoring pleasure. Since our new "Detergent-Action" Gasolines do both, they're prime examples of Standard's planning for you.

Standard has built 4 catalytic reformers in the West to make these cleaner-burning, more powerful motor fuels required for best performance of today's higher compression engines. This program was two years in planning and building—cost $50 million.

This $50 million worth of plants is only part of the $350 million Standard is investing this year to make petroleum more useful and plentiful. Some of it will go for product research, part will pay for new manufacturing facilities. A good share will finance the search for new sources of oil to help supply the 733 gallons a year per person that go into thousands of oil-born products essential to modern living.

So the $350 million is an investment in your future as well as ours. It's one way Standard helps guarantee there'll be plenty of oil to do more jobs today and in the years to come.

STANDARD OIL COMPANY OF CALIFORNIA

plans ahead to serve you better

For more data on advertised products, use Readers' Service Cards, last page

and can be varied from the control panel. Any stray radiation is trapped by the thick concrete walls of the tower in which the gun is housed. Radiation can be stopped by a master switch, thus allowing scientists to enter the tower immediately and adjust apparatus in the target area.

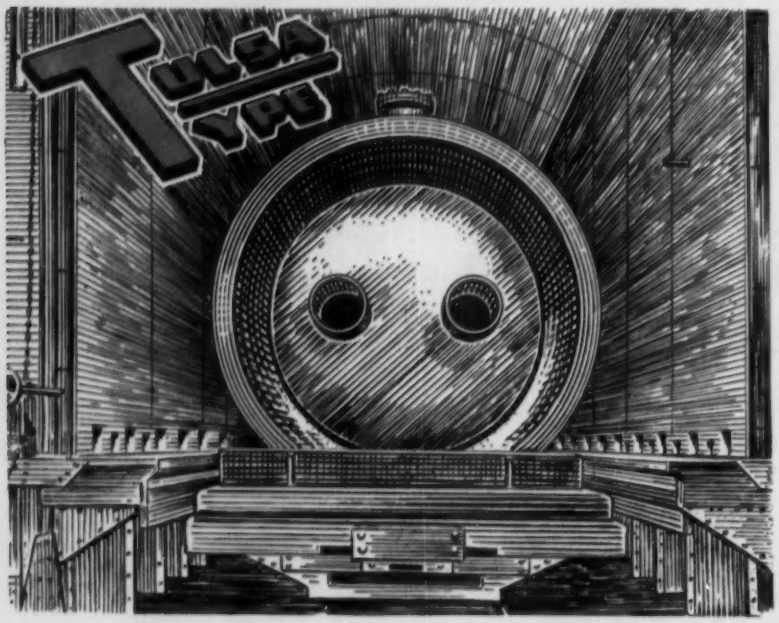
During operation, scientists are protected by elaborate inter-locking switch circuits, which automatically shut off the gun if any of the lead-lined doors in the tower or control room are opened. In the tower wall, a viewing port made from two plates of glass separated by 18 inches of zinc bromide solution, safely stops radiation when Atlantic's observe reactions occuring under the gun.

A simulated nuclear reactor, designed to teach "the feel" of operating a reactor, but with no fissionable materials involved, has been brought to market by Leeds and Northrup Company.

Called a "nuclear reactor simulator assembly," the device provides a scale-model "reactor core," and a full size control panel. Instead of using a fissionable material, the simulator has an analog computer which merely simulates the reactions of an actual atomic reactor.

Changes Firm Name

Socony Vacuum Oil Company of Canada, Ltd., has changed its name to Mobil Oil of Canada, Ltd. This follows the change in the parent company's name, made to bring the firm name into line with the name under which its products are marketed.



TURKISH BATH for TIRED TOWERS

Steel plate suffers from stress and strain, even as you and I. So, FLINT STEEL puts completed units through a stress-relieving treatment, in this giant 85-foot long, car-type bake oven. Heated up to a minimum of 1100 degrees Fahrenheit, the molecules in these steel plates "relax", and the stress-free tower which emerges will be stronger — more durable. Just one more example of the careful engineering and processing which go into each piece of TULSA TYPE equipment made only by FLINT STEEL CORPORATION.

Write for our General Catalog

BUILT Right

FLINT STEEL CORPORATION
TULSA, OKLAHOMA

Commission Recommends Selling Shale-Oil Plant

The Hoover Commission has recommended that the government dispose of its shale-oil production facilities at Rifle, Colo. The committee's report called for ending production and selling the retort. The plant already has been shut down.

Earlier, Congress had appropriated $1 million to allow the Bureau of Mines to continue mining operations in the Rifle area, but ordered the bureau to end production of shale oil. The bill provided that the retort must be closed but did not require that it be sold.

Meanwhile, the bureau reports that it will undertake a "special research program" to develop a safer and more economical method of mining shale oil, under the $1-million approriation. The bureau is studying several mining methods and hopes to test at least two that look promising.

Synthetic-Rubber Output Balances Consumption

World consumption of synthetic rubber balanced production at 505,000 tons during the first six months of 1955, the Department of Commerce has reported. This total does not include countries in the Soviet bloc.

For the same period last year, production ran 351,211 tons with consumption reaching 372,500 tons. Consumption of both natural and synthetic rubber in the U. S. during the first half of 1955 was 770,701 tons, an increase of 23 percent over the same period in 1954.

Imperial Oil Forms Petrochemical Unit

Imperial Oil, Ltd., has formed a new Chemical Products department to handle its manufacture and sale of petrochemicals. The department, to be headquartered in Toronto, will consist of two divisions.

The sales group will market products and offer technical assistance to customers, while working on the development of new uses for petrochemicals in Canada. The main job of the technical division will be to select and plan production processes.

Three Refining Companies Plan Michigan Merger

Three Michigan refining companies have signed an agreement to pool their facilities. The merger, still to be approved by the stockholders, was made between officials of Leonard Refineries, Inc.; Mid-West Refineries, Inc., and Roosevelt Oil and Gas Company.

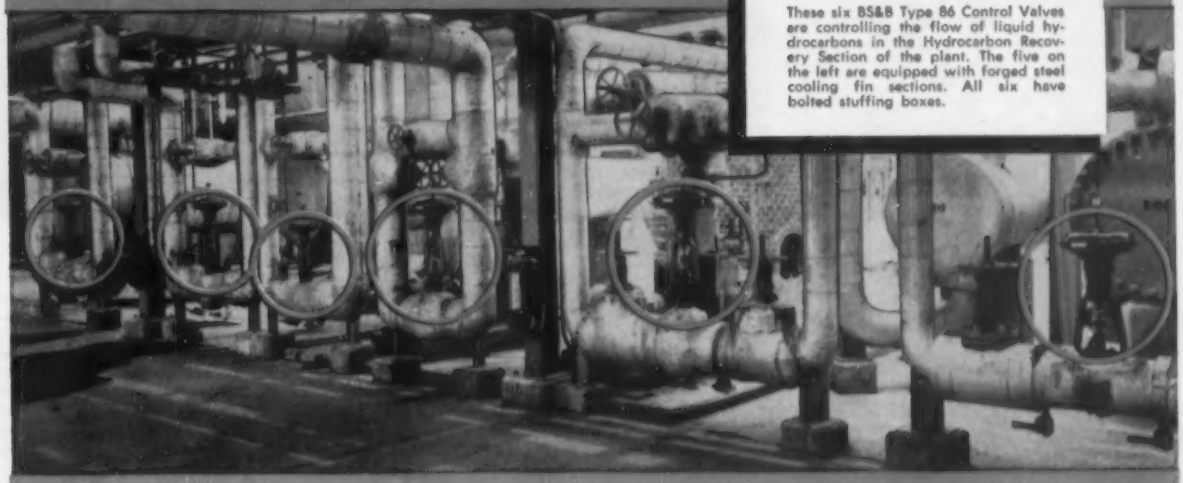
Both the Leonard and Mid-West companies operate refineries at Alma, Mich., and Mid-West has a plant at Grand Rapids. Roosevelt facilities are at Mt. Pleasant, Mich. Plans call for the transfer of Mid-West and Roosevelt assets in exchange for Leonard securities.

Test Stations Weather East Coast Hurricanes

Recent hurricanes which lashed the East Coast did no serious damage to testing facilities operated by Sea Horse Institute, Wrightsville, N. C., corrosion research

For more data on advertised products, use Readers' Service Cards, last page.

Where *Dependability* Counts Most...



These six BS&B Type 86 Control Valves are controlling the flow of liquid hydrocarbons in the Hydrocarbon Recovery Section of the plant. The five on the left are equipped with forged steel cooling fin sections. All six have bolted stuffing boxes.

BS&B Automatic Controls Get The Job!

One of the largest petro-chemical plants in the world is that of the National Petro-Chemicals Corporation at Tuscola, Illinois. This $50,000,000 plant extracts the heavier hydrocarbons from natural gas and converts them into fuels and chemicals used in the manufacture of plastics, synthetic fibers, fertilizers, detergents and dozens of other useful products.

This plant is largely automatic, thanks in large measure to numerous BS&B Pressure Control Pilots and Liquid Level Control Pilots—and to *more than 200* BS&B Automatic Control Valves in plant service!

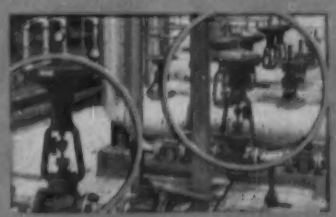
Valves range in size from ¾" to 8", many supplied with special body materials. Body types range from screwed globe cast iron valves to 600# ring type joint, flanged globe steel valves. Some were supplied with Haveg Bodies.

Valve trim included such materials as stainless steel and Hastelloy "B". Several valves in strategic plant locations were furnished with our Type Y Side Handwheels for emergency operation in the event of an operating medium failure. Some, destined for high temperature operation, were equipped with finned cooling sections. Many were furnished with valve positioners, either yoke mounted or mounted in the diaphragm case.

But however specialized the application, each BS&B Control was selected for the job because of its *dependability*...so vital to the successful operation of so complex a plant!

Next time you have a project in the planning stage, why not discuss the controls aspect of it in *strictest confidence* with our representative to be sure you get the *very best* controls for the job to be done?

For Better Regulation of Pressures, Temperatures, Liquid Levels or Flow, Equip Your Process With BS&B AUTOMATIC CONTROLS and SAFETY HEADS!



These six Type 86's, also with bolted stuffing boxes, are controlling the flow of fuel gas to the still heater in the Hydrocarbon Recovery Section of the plant.

These three BS&B Control Valves are on ethylene service in the Ethylene Section of the plant. On the left is a BS&B Type 73 DC Pressure Balanced Control Valve. In the center is a Type 86 with Finned Cooling Section and Jumbo Diaphragm. On the right is a Standard Type 86 with Large Topworks.

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.
Controls Division, Dept. 4-F9
7500 East 12th Street Kansas City 26, Missouri

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening. . .

group. Considerable damage was done to the institute's equipment last year, when Hurricane Hazel struck the North Carolina coast.

Water did not rise as high this year as during the Hazel storm, and none of the motors and equipment at Harbor Island was damaged. No racks or specimens were lost at the Kure Beach station, and both the institute's test lots remain in good condition.

Motors at Harbor Island were raised to a safe height for Hurricane Connie and left there until Diane went by. The motors were replaced as soon as the hurricane passed, and the island test station was returned to operations.

Anti-Pollution Plant Approved for Union Oil

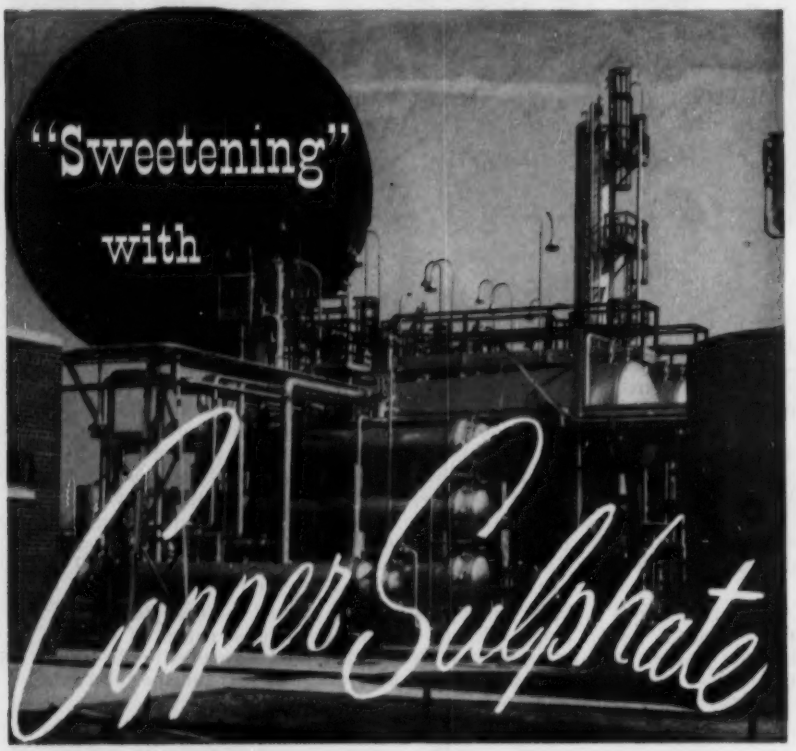
Union Oil Company of California has been granted an operating permit for a sulphur-recovery installation at its refinery in Wilmington, Calif. The permit was issued by the Los Angeles County Air Pollution Control district.

Union's $152,000 plant is designed to eliminate more than 70 tons a day of sulphur-dioxide gas emmission. The unit will remove all but 5.6 tons of the gas emmitted.

An estimated 418 tons a day of contaminating gases are being removed from the atmosphere over Los Angeles. The gases are being recovered by six plants now in operation within the county.

Wins Safety Award—

The highest recognition obtainable from the National Safety Council has been given to General Petroleum Corporation, for its 1954 safety record of 2.74 accidents per one million hours worked. The council's Award of Honor was presented by the vice president of its Industrial Conference, Max A. Koffman (center). Robert L. Minckler (right), is shown congratulating John McKenzie, head of General's Safety department.



Refiners! Triangle Brand Copper Sulphate is the right reagent for your oil sweetening process. Triangle Brand Copper Sulphate is available in grades for use in dry form when oil must be partly desulphurized, or for aqueous solutions to remove mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates. Use Triangle, it's 99% + pure.

PHELPS DODGE REFINING CORPORATION
40 Wall Street, New York 5, N.Y.
5310 West 66th Street, Chicago 38, Ill.

Government to Sell Last Rubber Plant

Companies interested in buying the government-owned synthetic-rubber plant at Institute, W. Va., have until October 7 to submit proposals to the Rubber Producing Facilities Disposal Commission. The Institute plant is the largest of the government-built copolymer plants.

No bids were received for the installation in the commission's original negotiations which resulted in the sale of 25 other plants. Negotiations for its sale were reopened, however, by a recent bill signed by the President.

Underground LP-Gas Stocks Show Increase for June

Underground stocks of LP-gases on June 30 totaled 303 million gallons, an increase of 73 million gallons during the month. The U. S. Bureau of Mines reported that, of the total, 253 million gallons were concentrated in Mississippi, Louisiana, Texas and New Mexico, while the balance was distributed through New York, Michigan, Illinois, Kansas, Oklahoma and Montana.

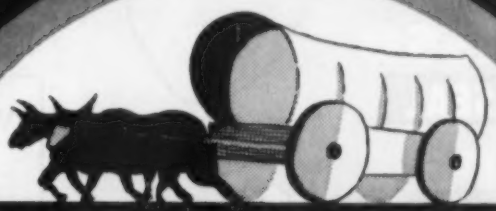
Underground stocks of propane totaled 182 million gallons, an increase of 49 million gallons. Butane stocks totaled 102 million gallons, 21 million gallons more than at the end of May. End-of-the-month butane-propane mixture stocks totaled 19 million gallons, showing an increase of 3 million gallons over stocks for the previous month.

Silver Anniversary Marked

Last month marked the 25th anniversary of the delayed coking process, developed by Standard Oil Company (Indiana) for heavy residual fuels and first put into commercial operation in mid-August 1930. The process still accounts for nearly three-fourths of the U. S. oil coking capacity.

Delayed coking made its advent as diesel locomotives were replacing oil-burning

PATENT CHEMICALS, INCORPORATED



MANUFACTURERS OF DYES AND CHEMICALS FOR THE PETROLEUM INDUSTRY

Your dependable source for...

Fluorescent colors and blooming agents used with additive compounded, solvent extracted lube oils
Dyes for gasolines, greases, waxes and industrial products
Petrol Ero Blue for Aviation gasoline
This material meets Mil-F-5572 Specification

Manufacturers of fluorescent indicator for F.I.A. absorption method hydrocarbon analysis. 'Petrol' Red AB4, a specially developed red dye for gasoline marking to meet Mil-F-5572 specifications. 'Petrol' colors for gasoline, kerosine, Diesel and tractor fuels. • 'Greasol' colors for greases. • 'Stero' colors for waxes.

Patent Chemical Company specializes in petroleum problems and preparation of particular products to meet special requirements involving dyes; fluorescent colors; additives; blooming, wetting, dispersion agents, etc.

SPECIAL PRODUCTS—

Fuel Oil Additives
Turbine Oil Additives
Petrol Blue Whiteners
Deblooming Agents
Gasoline Additives
Body Colors
Asphalt Bonding Agents
Dispersing Agents

PATENT CHEMICALS INC.
Manufacturing Division: 335 McLean Blvd., Paterson 4, New Jersey

PATENT FUELS & COLOR CORP.
Marketing Division: 2410 Carew Tower, Cincinnati 2, Ohio

More than a mere pipe fitting!
catawissa
PERFECT SEAL
unions
give a 3 to 1
safety factor
PLUS
A PERFECT SEAL!
THERE'S A CATAWISSA PERFECT SEAL UNION FOR EVERY USE . . . ALL TEMPERATURES, ALL PRESSURES!
The full dependability of HOT FORGED STEEL is yours in a Catawissa Union (hot forged from solid steel bars) with several extra value features that are exclusive here at the UNION SPECIALISTS!
All Catawissa Unions are designed to give a 3-to-1 SAFETY FACTOR . . . 3,000-lb. service unions are tested to 9,000-lbs., 6,000-lb. service unions tested to 18,000-lbs., etc.
Exclusive Ball-to-Angle seat design assures a PERFECT SEAL even when the pipe is not in alignment!
Machining operations assure a UNIFORMITY AND ACCURACY heretofore found only in special fittings and, with rigid inspection both during and after machining, guarantees LEAKPROOF CONSTRUCTION!
Satisfaction is guaranteed in any application—whether it be general low pressure service or extremely high pressures and temperatures (for air, oil, gas, chemicals, hot oils, gases or steam).
WRITE FOR CATALOG 11
AVAILABLE FROM LEADING INDUSTRIAL SUPPLY FIRMS
CATAWISSA VALVE & FITTINGS COMPANY
25 MILL ST. ★ CATAWISSA, PENNA.

What's Happening. . .

steam locomotives, also served a need as gasoline octane numbers began to increase and feed was required for giant catalytic crackers. American Oil Company is building delayed coking facilities at its new refinery near Yorktown, Va.

Dr. Robert E. Wilson, now chairman of the board and chief executive of Indiana Standard, was inventor of delayed coking. The patent for the process—one of more than 90 patents issued to Dr. Wilson—was filed in December 1928.

What's Ahead in 1976

The 1955 Oil Progress Week will be touched off by a one-hour television show, "1976," picturing what the public can expect from technology 21 years from now, with particular reference to what can be expected from the American petroleum industry. The show, sponsored by API's Oil Industry Information Committee, will appear over NBC-TV network Sunday, October 9.

Texas Company Names Union in Damage Suit

The Texas Company has filed suit in federal court at Camden, N. J., for $74,226 in actual damages resulting from breach of contract by an international union and its local bargaining agent representing hourly employes at the company's Eagle Point Works at Westville, N. J. Named as defendants are Oil, Chemical and Atomic Workers International Union, CIO, and Westville Local 12-638, OCAWIU-CIO.

The company alleges that on June 20 the unions violated their contract by engaging in a strike and work stoppage. Failure of employes to report for work caused the refinery to be shut down, the complaint states. This and subsequent starting up of operations resulted in the damages for which the company seeks judgement.

R. H. Aitken, superintendent of Eagle Point Works, said that the labor contract in effect between the unions and the company provided that the unions would not engage in a strike or work stoppage. He said that the unions breached this provision of the contract when Eagle Point employes within their bargaining jurisdiction refused to report for work while supporting the strike of the National Maritime Union against the company's tankship operations.

Aitken further stated that in the interests of stable future relations, the company was requesting the court to decide the difference of opinion between the company and the union as to whether or not the contract had been breached.

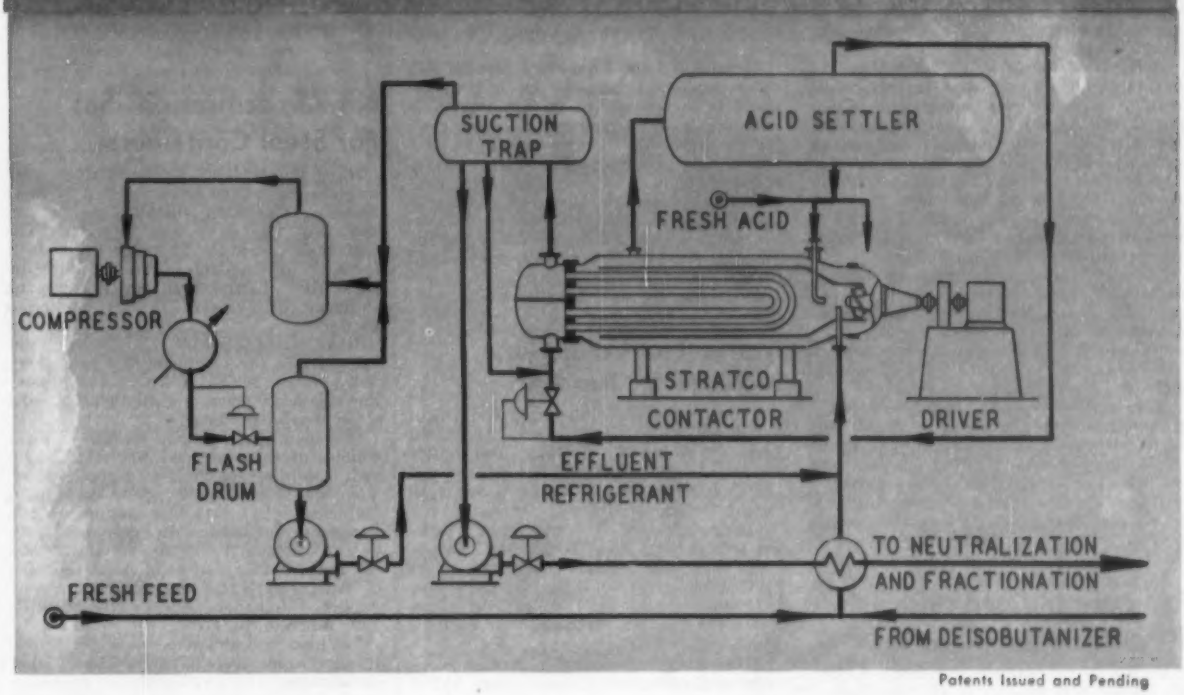
Fifteen Companies Seek To Run Greek Refinery

Some 15 international oil companies have indicated an interest in operating the Greek government's projected refinery at Pireaus.

Included among the companies which submitted applications to operate the 30,000-barrel-a-day plant and market its

STRATCO
Reg. U. S. Pat. Off.

Something New in ALKYLATION



Patents Issued and Pending

This is the type of reaction system used with the new horizontal Stratco Contactor to give the high yield of high quality alkylate, with low catalyst consumption, described on pages 148 - 151 of this issue.

STRATFORD ENGINEERING Corporation
612 West 47th St. — PETROLEUM REFINING ENGINEERS — Kansas City 12, Mo.

For more data on advertised products, use Readers' Service Cards, last page.

products in Greece were Socony Mobil Oil Company, Inc., The California Texas Oil Company, Ltd., The British Petroleum Company, Ltd., Compagnie Financiere Belge de Petroles, S.A. (Petrofina), the Royal Dutch/Shell group and American Independent Oil Company.

The government's decision on a refinery operator is not expected for several months. The refinery is scheduled for completion in about two years.

U. S. Octane Ratings Continue to Climb

Octane ratings of gasoline on sale at service stations in August showed a nationwide weighted average of 95.9 for premium and 88.5 for regular, according to a monthly survey of 53 cities conducted by Ethyl Corporation.

The rating for premium grades was 0.1 octane number higher than in July, while regular gasoline was unchanged. Compared with August 1954, premium gasoline was 2 octane numbers higher and regular gasoline was up 1.6 octane numbers.

Average tetraethyl lead contents in August were 2.59 ml a gallon of premium gasoline, as against 2.57 ml for July, while regular grades scored 2.27 ml a gallon as compared with 2.21 ml for July.

Of the 53 cities covered in the Ethyl survey, 27 showed increases over July on premium, with ten gaining 0.5 octane number or more. In regular gasoline, 24 cities had a higher average antiknock quality than in July, with eight showing a gain of 0.5 octane number or more.

The survey was based on some 850 gasoline samples purchased by Ethyl representatives in the 53 marketing centers.

The highest octane rating for premium was found at Corpus Christi, Texas, where an unweighted arithmetic average hit 97.3 octane numbers. For regular, the metropolitan New York, New Jersey area was leader with a 90.6 average.

Refinery Industry Shows 1955 Increase in Profits

Profits in the petroleum-refining industry for the first quarter of 1955 amounted to $756 million before taxes, as compared to $735 million for the corresponding period in 1954. These figures were released in a Federal Trade Commission report showing refineries' profits totalling $750 million for fourth quarter in 1954.

After taxes were paid, refineries made a $575-million profit for the first quarter of 1955, compared with $662 million for the fourth quarter of 1954 and $543 million for the first quarter of 1954.

Power Needs to Increase

The world oil industry will be supplying 1.5 billion tons a year by 1980, C. M. Vignoles, managing director of Shell-Mex & B. P., Ltd., has predicted. This is compared to the world's present output of 700 million tons.

Vignoles said world energy requirements will be doubled by 1980 and, until atomic power becomes significant, the oil industry will need to make increasing contributions. He estimated capital expenditures by the industry will be about $5.5 billion a year for the next 20 years.

Ninety Percent of Refinery Saved from Fire and Blast

Standard Oil Company (Indiana) officials expected to have the undamaged refining equipment at Whiting, Ind., back in operation before September 15. All operations at the refinery have been suspended since the explosion and fire which hit the plant August 27, seriously damaging a new 50,000-barrel-a-day Fluid Hydroformer and destroying some 10 percent of the refinery area.

Damage to the plant was estimated at more than $10 million, of which all but $1 million was covered by insurance. Most seriously damaged were the new Hydroformer, where the fire started, and a sweeting and treating plant.

The fire started when an explosion occurred in the Hydroformer, a new unit in commercial operation since March. The unit had been closed down for repairs and was being started up again when it was ripped apart by the explosion. The structure was leveled.

Despite the fire, supplies of gasoline and other products were sufficient to meet demand in the company's market area. Normal supplies were maintained by the company's system of interlocking pipe lines which connected Standard refineries to distribution points.

Company officials have met with government representatives to discuss the possibility of federal aid for rehabilitating the Whiting refinery. Presumably, government help would come in the form of rapid-tax amortization for new installations.

Motor Tax Collections Increase 6.1 Percent

State motor tax collections amounted to $2353 million during the fiscal year ended June 30. A Bureau of the Census report shows collections for 1955 as 6.1 percent more than the $2218 million taken in during the previous year.

California lead the country in motor-tax collections, taking in some $250 million. Other states collecting more than $100 million in 1955 were Pennsylvania, $138 million; Ohio, $126 million; New York, $119 million; Illinois, $117 million, and Texas, $113 million.

Total state collections from motor vehicle and operators licenses were $1184 million, an increase of 7.9 percent from the previous year.

Texas Refinery Picketed

Republic Oil Refining Company was hit by a strike at its Texas City, Texas, refinery, following the lay off of 33 clerical workers. The plant was being picketed 24 hours a day by members of Local 4-449 of the Oil, Chemical and Atomic Workers International Union (CIO). The clerical workers are represented by the same union as plant workers.

Conoco Wins Award

For the third consecutive year, Continental Oil Company has won the National Safety Council's Award of Honor. The company had 71 percent less lost-time accidents than the oil-industry average for 1954, and its number of days lost because of accidents was 93 percent below the average for U. S. industry as a whole. Conoco is the first petroleum company to win the award three years in a row.

Petroleum Consumption Forecast Revised Upward

The Bureau of Mines has revised upward to 3136 million barrels its forecast of total demand for all petroleum products in 1955. The prediction represents an increase of 6 percent over demand for 1954, or double the 3 percent increase expected in January, when the bureau forecast a need for 3048 million barrels.

Shell Group Organizes Chemical Firm in U. K.

The Shell group has formed a new company to handle all its chemical manufacturing in the United Kingdom and Erie. The new firm, Shell Chemical Company, Ltd., will be capitalized at some $28 million. Petrochemicals, Ltd., recently acquired by Shell, will be operated as a wholly-owned subsidiary of the new company.

New Specifications Set For Steel Containers

Three standards for steel container specifications have been recommended by Steel Shipping Container Institute, an organization of container manufacturers. The specifications are for 55-gallon drums conforming to Interstate Commerce regulations 5B, 17C and 17H, which cover the shipment of regulatory, or dangerous products.

Regulations 5B and 17C cover tight-head drums for shipment of liquid products, which ICC-17H covers a fully-removable-head drum for shipment of solid or semi-solid products.

The new specifications are the first additions to recommended universal standards published by SSCI in October 1954. They have been approved by the Manufacturing Chemists Association's Metal Packages committee, the Packaging Institute's Petroleum Packaging committee and the Bureau of Explosives of the Association of American Railroads. They also were published as Federal Specification PPP-D-729, Amendment 1.

Detailed specifications, now being distributed to members of the SSCI and other associations, are available to container users upon request to the Steel Shipping Container Institute, 600 Fifth Avenue, New York 20.

Rocky Mountain Firms Complete Merger Plans

A merger between Mountain Valley Oil Corporation, a Denver concern, and Black Thunder Oil-Uranium, Inc., a Rapid City, S. D., firm, has been approved by the stockholders of both companies. Mountain Valley will be the surviving company.

Black Thunder's assets included a gasoline plant near Newcastle, Wyo. The merger was on the basis of exchange of 30 shares of Black Thunder for one share of Mountain Valley.

To Close German Plant

Deutche Gasolin Aktiengesellschaft will shut down its 1800-barrel-a-day Dollbergen refinery. Reason given for the shutdown is the high cost of moderinizing the plant.

DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

September ★ *One of a Series of Interest to the Petroleum Industry* ★ *1955*

Fast-rolling "MAGIC BARREL" now smaller, lighter

As a public relations tool for individual refiners and the petroleum industry, the "Magic Barrel" shows steadily increasing value.

In the first quarter of 1955, more than twice as many "Magic Barrel" presentations were made as were made in the same period of 1954. In March alone, an audience of 66,789 witnessed the presentation.

Now to make it more convenient for speakers who make the presentation, a smaller, lighter barrel is available.

The number of shelves has been cut from 16 to 9. This has been done without sacrificing any props or audience interest. As a further convenience, the new barrel can be divided into two units. A performance can be made with each half.

Created originally by the Du Pont Petroleum Chemicals Division for Oil Progress Week observances, arrangements for "Magic Barrel" presentations are now handled by the OIIC.

ASHLESS additive to help you curb oil burner ignition failures

You can now use a single additive to do two important jobs.

As a stabilizer and dispersant, Du Pont Fuel Oil Additive No. 2 does a highly efficient job of preventing sludge formations that cause filter fouling and nozzle plugging.

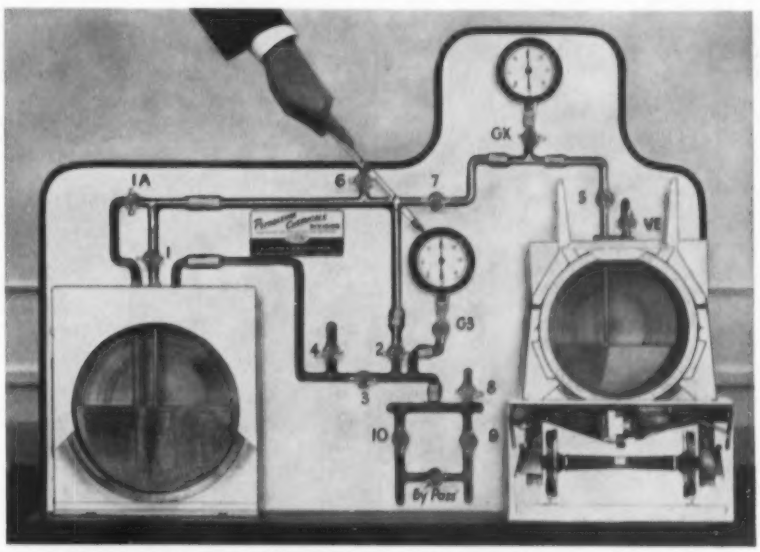
In addition, it offers an important plus value by minimizing ignition failures. How?

Being a nonmetallic *ashless* additive, it does not leave a metallic ash deposit which can foul the operation of the electrical system. Thus it helps to *eliminate many of the service calls* that cost your distributors time and money . . . and even loss of business through customer dissatisfaction.

Added to freshly prepared stocks at the refinery, FOA-2 retards the formation of insoluble residues during storage . . . keeps oil free flowing and clean burning . . . helps clean out sludge deposits that clog burner filters, screens and nozzles.

Many Du Pont contributions to safer, more efficient, TEL handling

Because the handling of tetraethyl lead is such a critical job, developing ways to do it safely and efficiently is a constant challenge. One of the main purposes of the Du Pont Petroleum Chemicals Division's operations group is to help refiners in this important work.



THIS HYDRAULIC WORKING MODEL exactly simulates with mercury the operation of a TEL eductor system . . . makes an ideal tool for training blending plant personnel.

By approaching the problem from different angles, Du Pont has been able to make a number of valuable contributions. One of these is . . .

New gage adaptation

Failure of the gage used in checking eductor efficiency during TEL blending is frequently costly to refiners in lost time and wasted manpower, as well as in the actual cost of repairs. This gage failure has often occurred when excessive pressure at shutdown or startup strains the gage, rendering it inaccurate or inoperable.

To correct this problem, we are providing a new type of gage that resists pressure damage. Its indicator needle is controlled by a grooved shaft. When the pressure limit—maximum pressure indicated on dial face—is reached, the needle and shaft disengage. When pressure drops, they automatically link together again—without damage to accuracy.

Large numerals on the gage face make it easy for operators to read pressures accurately within relatively close tolerances over the full range, both positive and negative.

Model helps in teaching

Another recent development of the operations group is a unique model of a blending plant which can be used as a working, visual training aid. Vacuum operated, it simulates actual blending plant operations. By presenting the

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OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED

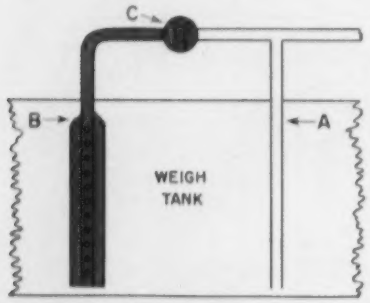
TEL Services

system as two simple mechanical functions – unloading and blending – it makes an ideal tool for giving new employees a graphic understanding of TEL handling operations. It can be used to demonstrate safety procedures and establish standard handling methods. And large groups can receive identical instructions at a single sitting.

Siphon problem ended

Until about a year ago, siphon breaks caused by leaks in the vacuum system often posed a serious TEL unloading problem for refiners. Then a Du Pont engineer in the operations group came up with the solution . . . and a special pipe that acts as a siphon starter was made available to refiners.

The Du Pont-designed siphon starter is entirely confined within the weigh tank. And the starter itself is surrounded by a perforated outer shield which eliminates any danger of explosion from a static charge.



THIS DIAGRAM EXPLAINS the basic principles in the Du Pont siphon starter system. "A" represents the standard standpipe. "B" indicates the perforated standpipe and shield. "C" is the siphon starter valve.

Metal-Flex hose

Still another Du Pont contribution to TEL unloading efficiency was the development of the Metal-Flex TEL unloading line. Because it is flexible, it does away with packing glands which sometimes result in leaks on other types of lines. The Metal-Flex hose requires only one man to hook up and operate.

Continued—middle of next column

Du Pont Metal Deactivator Now Approved for Use in Military Jet Fuels

A military specification, MIL-F-5624C, has been issued approving the use of metal deactivators in military aviation jet fuels. Du Pont Metal Deactivator, "DMD," complies with this specification.

In this new use, DMD protects against the harmful effects of active copper and other metallic compounds which have a detrimental effect on jet fuel stability. Its use is especially important for stockpiling and overseas operations where the storage periods and distribution lines are extra long.

Another important advantage of using DMD is the greater blending flexibility it provides. In this way, it increases substantially the availability of blending stocks that can be used for military jet fuels.

The government specification permits the use of a maximum of 2 pounds of active ingredient of metal deactivator per 1,000 barrels of jet fuel. Methods of addition and other information on the use of DMD are included in the recently published Du Pont Metal Deactivator book. If you do not have a copy, ask any of our representatives or regional offices to send you one.

Your special problems

Although we are not in the equipment design business, our operations group is always ready to help you with your individual TEL handling problems, *whatever* they are. And the above improvements are a result of this service, which also includes engineering help with blending plant design and construction—all the way from site selection to personnel training.

To help US . . .

continue to develop improvements in TEL handling, please tell us your problems. Just address your request for service to any of our representatives or regional offices listed below.

WEST COAST LAB MANAGER

JAY BRENT MALIN

A background as internal combustion engine specialist, work in rocket motor development, and engine research and development for The Texas Company qualifies J. Brent Malin for his current assignment. He is manager of the Petroleum Chemicals Division's Regional Laboratory at El Monte, California. Previous to this, he was a technical representative in the West Coast area.

Mr. Malin joined the Du Pont Company in 1951 as an automotive technologist. In that capacity he devoted much time to assisting oil companies in solving product use problems. With automobile manufacturers, he worked on engine developments related to fuel and lubricants.

Malin came to Du Pont from North American Aviation. Prior to that time, he had been with The Texas Company for ten years.

He was graduated from the University of Utah with a B.S. degree in mechanical engineering. He is a member of SAE and a Registered Professional Engineer, State of California.

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What's Happening . . .

. . . *Among Men* in the Industry

Oliver F. Senn has been made chairman of the Chemistry department at Stanford Research Institute. He was promoted from assistant chairman, following a European tour as part of the institute's international liaison program. Visiting eight countries, he observed research in waste utilization and air pollution.

Before joining the institute in 1952, Dr. Senn was vice president and director of research on fine organic chemicals and dyestuff intermediates at Maumee Chemical Company in Toledo, Ohio. For five years, he was an associate professor at the University of Toledo, instructing in chemical engineering and physics.

R. A. Dresselly has been promoted to technical specialist in the Technical Service division at Humble Oil & Refining Company's Baytown, Texas, refinery. He holds both B.S. and M.S. degrees in chemical engineering from Massachusetts Institute of Technology. In his new position, Dresselly will be concerned with optimizing operations at the butadiene plant Humble recently acquired from the government.

Ashby J. Badger, executive vice president of Utah Oil Refining Company, has been elevated to president, succeeding **E. S. Holt,** who retired after 42 years with the Standard Oil Company (Indiana) affiliate.

Russell G. Dressler, who completed development of the incendiary bomb used by the U. S. in World War II and developed the basic formula for Dacron, has joined Southwest Research Institute as manager of chemical engineering research. He formerly was a chemical consultant in Wilmington, Del., where he served major chemical and explosives companies.

Dr. Dressler set up the first large-scale facility for obtaining gasoline from coal as chief of the $6-million U. S. Bureau of Mines demonstration plant at Louisiana, Mo. He designed the plant layout and directed its construction.

He supervised chemical production plants and took part in designing and building 15 of the plants while with the Chemical Corps during the war. He made final developments on the napalm-gel bomb and directed its mass production for the government. Before Dr. Dressler was placed in charge of the government's incendiary-bomb program, rejections were running as high as 25 percent.

The author of 20 published articles in the petrochemical and chemical process fields, Dr. Dressler holds seven patents, including the separation of para-xylene, used to produce the original material from which Dacron is made.

John E. Hull, retired Army general and former commander of U. S. and U. N. forces in the Far East, has been elected president of the Manufacturing Chemists Association. To be headquartered in Washington, D. C., he succeeds **William C. Foster** who resigned. See Page 388.

Stanvac Names Five

An organizational change involving the creation of five new top-management posts have been made in the New York headquarters of Standard-Vacuum Oil Company. Under the new set-up, countries where Stanvac does business are grouped into five major areas, each with a regional coordinator at New York in charge of integrated operations in his area. Those assigned to the new posts:

Rufus T. Burton, former general manager at Bombay and now coordinator for the South Asia and East Africa regions, including India, Pakistan, Ceylon, Burma, the East African countries, and Madagascar.

James D. Jacobs, previously managing director of Stanvac's Australian subsidiaries, named coordinator for Australia, New Zealand and the Pacific Islands, and temporarily assigned as coordinator for the South African region including the Union of South Africa, the Rhodesias and Portuguese East Africa.

Gerald L. McCoy, until recently general representative in Indonesia, appointed coordinator for Southeast Asia, including Indonesia, Malaya, Thailand and Indo-China.

Joseph A. Parrish, formerly a general manager in the Philippines, given responsibility for the Far East region, including the Philippines, Japan, Korea, Formosa and Hong Kong.

Collacott

Kovac

Robert H. Collacott, who since 1952 has been assistant to the chairman of The Standard Oil Company (Ohio), is now director of the company's public relations. Appointed as associate director is **Frank J. Kovac,** for the past two years assistant to a Sohio vice president.

Collacott, with the company since 1920, served during World War II as chief of the Price section in the OPA's Petroleum Products division. Kovac joined Sohio in 1947 as a staff assistant.

Joseph T. Wilson, Jr., has been elected assistant secretary and assistant treasurer of Sun Oil Company.

Robert W. Griffith has been named manager of Sunray Mid-Continent Oil Company's Gas-Gasoline division. Until recently assistant manager of Sunray's Refining department, he will be in charge of field-plant gas-product manufacturing.

With the company since 1948, Griffith has served successively as assistant superintendent of gas-gasoline operations, manager of the Gas-Gasoline department and assistant manager of manufacturing and pipe lines.

Loren Buck, who joined the company this summer, has been appointed chief engineer for the division. He formerly was with Stanolind Oil & Gas Company as chief project engineer.

Henry H. Hewetson, former chairman of Imperial Oil, Ltd., has been elected a vice president of Standard Oil Company (New Jersey). With the Jersey Standard organization 31 years, Hewetson has been a director of the parent company since 1950.

Carl A. Gerstacker, treasurer of The Dow Chemical Company, has been elected vice president, and **Robert B. Bennett,** assistant secretary was also made an assistant treasurer and appointed to the company's finance committee.

Two new assistant secretaries are **William A. Groening, Jr.,** assistant general counsel at Midland, Mich., and **Luther Evans,** an assistant general manager of the Texas division at Freeport.

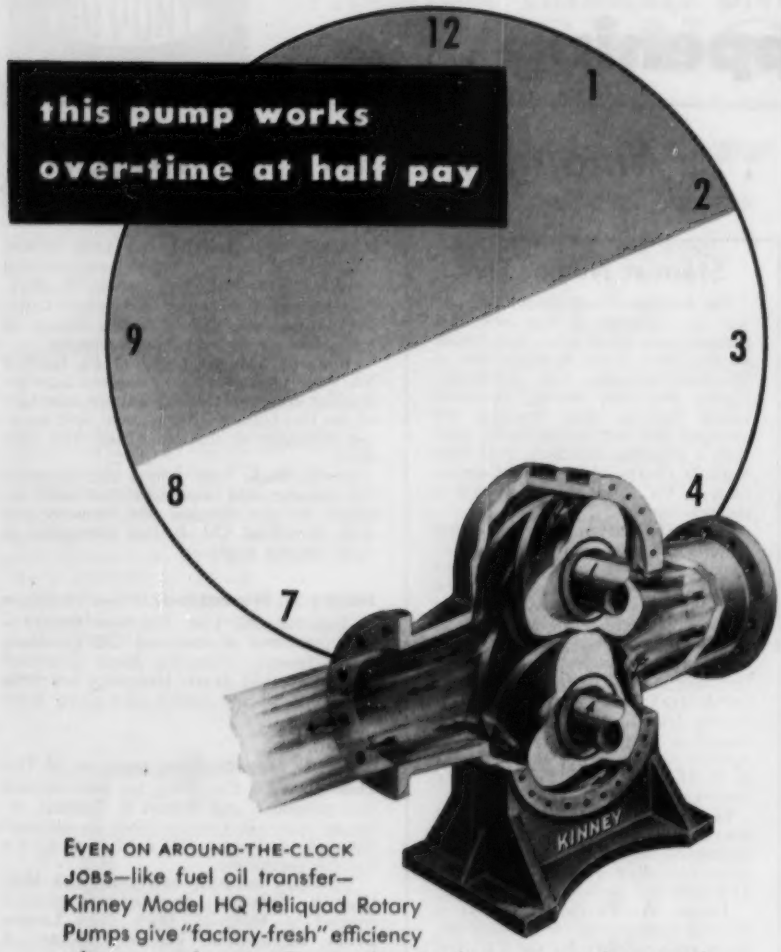
Gerstacker, who started with Dow in 1938, was first elected treasurer in 1949. Bennett has been with the company since 1942 and has been an assistant secretary since 1951. Both Groening and Evans joined Dow in 1937. Groening was named assistant general counsel in 1951, and Evans became an assistant general manager at Freeport last year.

Ernest E. Lyder has been elected president of U. S. Oil and Refining Company, successor to Pacific Oil and Refining Company. Dr. Lyder is former manager of the Standard Oil Company of California refinery at El Segundo, Calif.

Swanton D. Dalton, manager of the Refinery Engineering division of Socony Mobil Oil Company, Inc., is one of three receiving appointments to key positions in the company's Manufacturing department. He was named to a newly-created post of assistant general manager of manufacturing in charge of technical coordination.

Taking his place as manager of the Refinery Engineering division is **Edward L. Sinclair,** formerly general manager of the Socony Mobil refinery at Paulsboro, N. J. He, in turn will be succeeded by **L. Erlis Cranston,** promoted from assistant general manager at Paulsboro.

Dalton's career in the refining industry dates from 1933, when he joined General Petroleum Corporation, Socony Mobil's West Coast affiliate, at its refinery in Torrance, Calif. He moved to the parent



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What's Happening. . .

company in 1940, and served in various supervisory engineering positions before becoming head of the Refinery Engineering division and a member of the manufacturing committee in 1950.

Sinclair, with the company since 1938, served in various positions with the Refinery Engineering division and at the Paulsboro refinery, becoming assistant general manager in 1949 and general manager the following year.

Cranston joined Socony Mobil in 1931 at its Augusta, Kansas, refinery, and held various operating jobs before his transfer to the Manufacturing department in 1950. The following year he was named to the staff of the Paulsboro refinery, becoming assistant general manager in 1953.

Joseph L. Seger, executive vice president of The Carter Oil Company, has been elected to the board of directors of Esso Research and Engineering Company. **Stanley C. Hope,** president of Esso Standard Oil Company, and **Cecil L. Burrill,** chief economist for Standard Oil Company (New Jersey), have been moved to the executive committee of the Esso Research board.

Allen E. Smith, a staff engineer who has been doing engineering research on automotive fuels and lubricants for Socony Mobil Oil Company, Inc., is now chief engineer of the company's Aviation department.

With the company since 1936, Smith served as technical advisor to the Aviation Sales department during and shortly after World War II, and later was assigned to the Automotive division of the Lubricating department.

Kavanaugh W. Dodson, Jr., has been appointed director of public relations for Lion Oil Company. He succeeds **John H. Gray,** who is preparing to enter the priesthood.

Fredrick C. King, assistant engineering manager of the General Petroleum Corporation refinery in Torrance, Calif., has been made assistant to the plant manager.

King joined General Petroleum in 1941 as an inspector for the Engineering department at the company's refinery in Vernon, Calif. In 1946 he was appointed maintenance control engineer at Torrance, and in 1949 was moved up to assistant manager of the department.

A. L. Deaton has been appointed assistant general counsel of The Carter Oil Company. He succeeds **Walter Davison** who retired.

Ju Chin Chu has been promoted from associate professor to professor of chemical engineering at Polytechnic Institute of Brooklyn. As a distillation and process design expert, he is an active consultant in the petroleum refining and petrochemical industry.

William M. Yates, assistant director of The Dow Chemical Company's Patent department, has been named to succeed **Edward C. Burdick,** who is retiring after 18 years as head of the department.

Burdick, who has been engaged in patent

Holds together better than ever . . .

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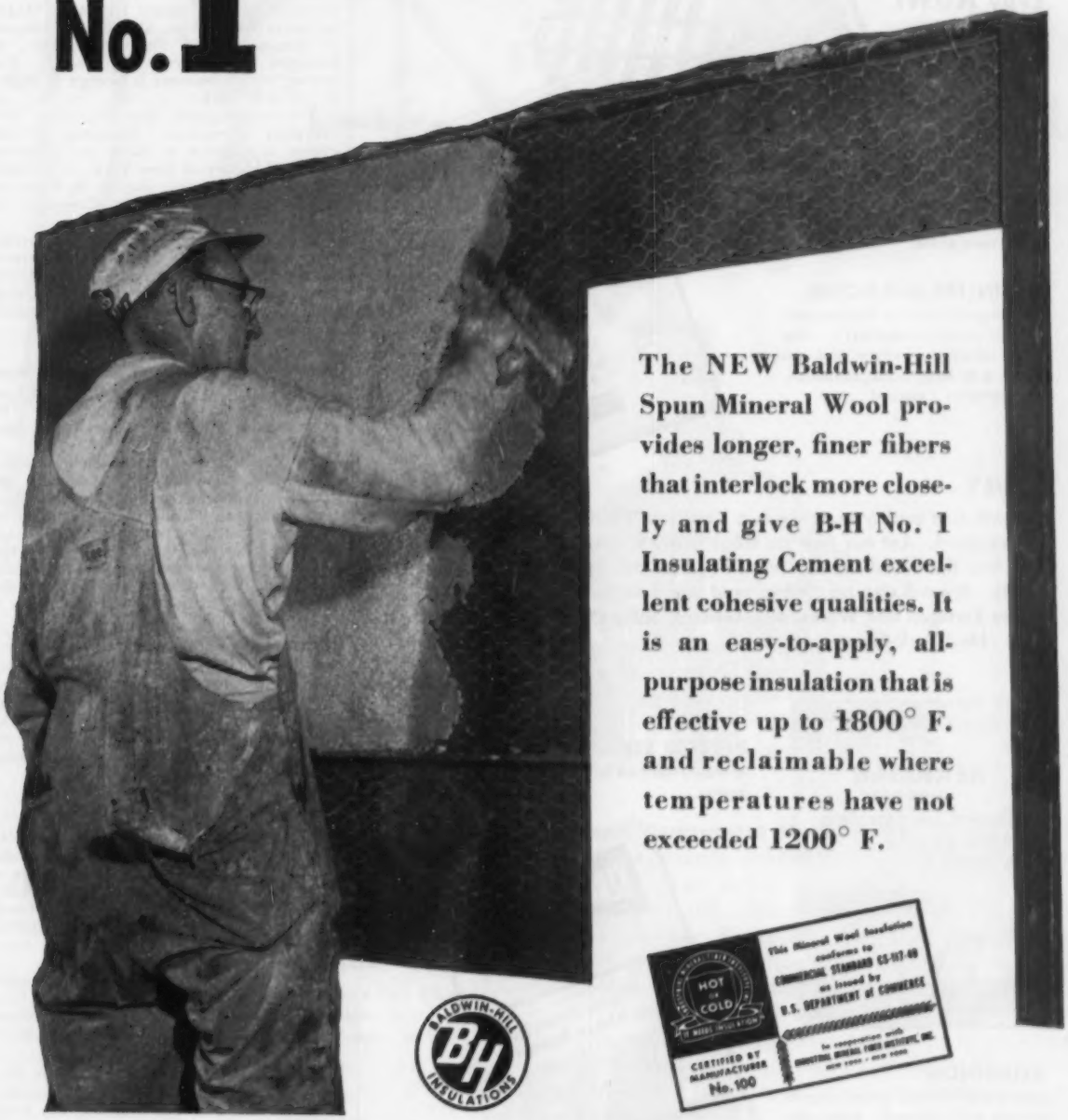
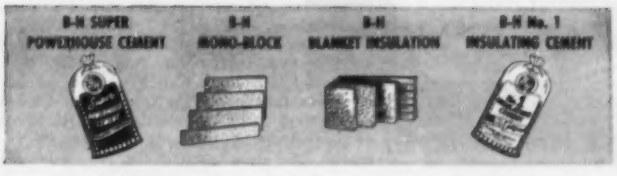


The NEW Baldwin-Hill Spun Mineral Wool provides longer, finer fibers that interlock more closely and give B-H No. 1 Insulating Cement excellent cohesive qualities. It is an easy-to-apply, all-purpose insulation that is effective up to 1800° F. and reclaimable where temperatures have not exceeded 1200° F.



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What's Happening. . .

work for Dow since he joined the company in 1928, will continue with the company as a consultant. Yates has been associated with the Patent department through most of his 20 years with the company. He had been assistant director since February.

T. E. Macy, with The M. W. Kellogg Company in New York, has been elected president of the Tubular Exchange Manufacturers Association, and E. E. **Dillman,** of Engineers and Fabricators, Inc., in Houston, was named vice president. The new secretary-treasurer is **George P. Byrne,** Jr., of New York.

The organization also elected a new executive committee. Members of the group, in addition to Macy and Dillman, are **T. H. Miley** of New York, with Foster Wheeler Corporation, and **G. B. Faust,** of Southwestern Engineering Company in Los Angeles.

The association, formed over 15 years ago, is composed of the manufacturers of tubular heat exchangers used in the petroleum, chemical and other processing industries. The group has published a standard on tubular heat exchangers.

Merlan M. Lambert is one of three new additions to the technical staff at Esso Laboratories in Baton Rouge, La. The others are **Michael F. McDonald** and **Charles M. White.**

Dr. Lambert received a bachelor's degree from West Virginia Wesleyan, together with bachelor's, master's and doctor's degrees in chemical engineering from West Virginia University. McDonald holds a B.S. in chemical engineering from the University of Missouri, and Dr. White completed his bachelor's and doctor's degree at Georgia Institute of Technology.

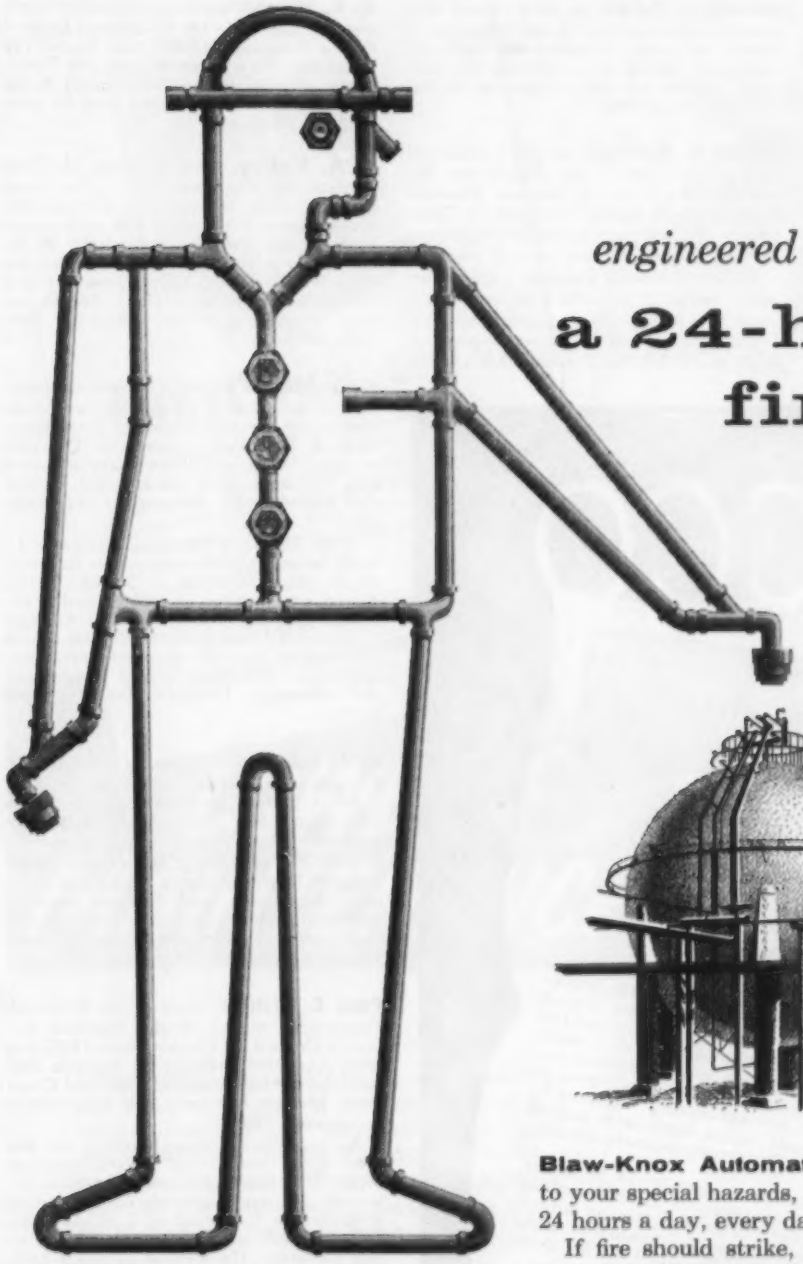
Thomas P. Simpson, vice president and director of manufacturing for General Petroleum Corporation, has just completed 30 years service with the company and its parent organization, Socony Mobil Oil Company, Inc. He was one of the developers of the thermofor catalytc-cracking process.

Kenneth E. McCulloh, a physical chemist, has joined the staff of the National Bureau of Standards, to study combustion mechanisms and kinetics. As a member of the Engine Fuels section of the Heat and Power division, Dr. McCulloh will investigate the fundamental chemical reactions which take place in fuel combustion.

Before joining the bureau, he taught physical and analytical chemistry at the University of Iowa. He has been co-author of several articles published in his field.

Francis E. Blacet, chairman of the Department of Chemistry at the University of California at Los Angeles, has been named to head a new Technical Advisory committee set up by the Air Pollution Foundation.

The petroleum industry is represented on the seven-man committee by **Dr. William A. Claussen** of San Francisco, executive secretary of API's Smoke and Fumes committee, and **Dr. Lawrence M. Richards** of Los Angeles, assistant manager of research and development for Richfield Oil



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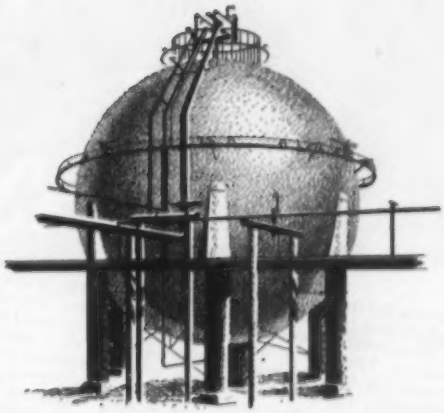

Blaw-Knox fire protection systems carry approvals of all insurance underwriters.

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Blaw-Knox Automatic Fog Systems, engineered to your special hazards, are fire guards that work for you 24 hours a day, every day in the year.

If fire should strike, your Blaw-Knox fire protection system will smother flames and dissipate heat quickly, thus checking possible loss of equipment and lives. It will also save you from such "hidden" dangers as loss of profits during downtime and loss of customers, possibly forever.

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What's Happening. . .

Company and former director of air pollution research at Stanford Research Institute.

Other members of Dr. Blacet's committee are **Dr. Arie J. Haagen-Smit,** professor of bio-organic chemistry at California Institute of Technology; **Charles M. Heinen** of Detroit, vice chairman of the Automobile Manufacturers Association's Vehicle Combustion Products subcommittee; **Dr. Peter Kyropoulos,** associate professor of mechanical engineering at California Institute of Technology, and **Dr. John T. Middleton,** professor of plant pathology at the University of California at Riverside.

Harold L. Curtis has been elected to a newly-created position of vice president in charge of public relations for Shell Oil Company. He has been directing the company's public relations as assistant to the president since 1947.

David H. Kirkeby has been appointed assistant manager of the High-Power Research department at Armour Research Foundation of Illinois Institute of Technology. He will be responsible for helping develop projects in new areas of research.

Kirkeby formerly was with Liquid Carbonic Corporation, which he served ten years as a member of its engineering staff. During World War II, he was a procurement officer for the Treasury Department.

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D. C. Wilson has been appointed supervisor of The Ohio Oil Company's General Office Personnel department. Formerly personnel officer in the Supply and Transportation department, he succeeds **F. G. Brucklacher** who has retired after 39 years with the company.

J. A. Kelley, vice president of Cities Service Oil Company (Pa.), has been made manager of marketing research and development. Succeeding him as manager of operations and manufacturing is **W. G. Swartz,** formerly superintendent of operations for the Kansas City region of Cities Service Oil Company (Del.). Swartz has been transferred to the company's New York office.

K. D. Bowen has left Celanese Corporation of America to become general manager of the recently-organized Texas Butadiene & Chemical Corporation. The new company plans to build an alkylate-avgas and butadiene plant at Houston. Bowen also will serve the company as vice president.

With The Dow Chemical Company 17 years before joining Celanese as manager of its chemical plant at Bishop, Texas, Bowen was director of manufacturing coordination for Celanese when he resigned to accept his new position. He also served Celanese as manager of plant operations, and while with Dow he was manager of the company's Freeport, Texas, styrene plant.

E. J. Fox, former superintendent of the Carbide and Carbon Chemicals Company plant in Texas City, Texas, has been appointed assistant works manager for the company.

With Carbide and Carbon since 1930, he served successively as production engineer, department head, chemical area supervisor, assistant plant superintendent and superintendent of company plants in Texas City and Louisville, Ky.

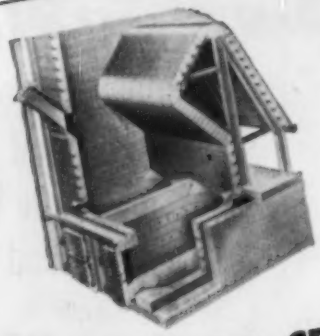
Paul E. Gishler, head of the Chemical Engineering section of the National Research Council in Ottawa since 1943, has been appointed manager of research and development for Canadian Chemical Company, Ltd. He had been with the research group since 1936.

As a principal research officer for the council, he worked on several projects aimed at developing Canadian natural resources. He was responsible for developing a method of extracting oil from Alberta's tar sands and cracking it into fluid oil in one operation. His method since has been extended to the treatment of other Canadian heavy crudes. He also spent a number of years on the atomic-energy project.

Frederick W. Dittus, since 1944 chief engineer of California Texas Oil Company, Ltd., has been appointed an assistant vice president. Another change in the company's personnel is **Robert R. Tillotson's** promotion to managing director of Caltex Oil Refining (India), Ltd.

Dittus is in charge of design and construction of refineries and other major facilities for the Caltex group. Tillotson, a veteran of 35 years with Caltex and Standard Oil Company of California, will operate the refinery Caltex is building at Visakhapatnam, India.

Tillotson joined SOCAL in 1920, became an analytical chemist and then held



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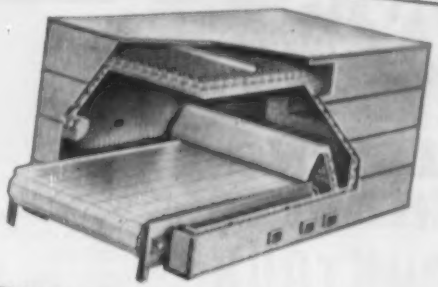

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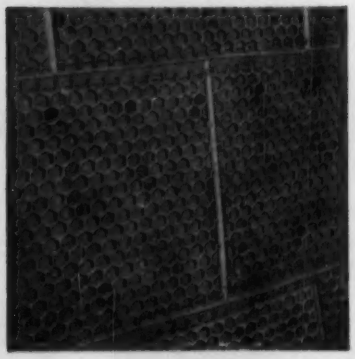

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What's Happening. . .

positions of increasing responsibility at various refineries and research laboratories. Before starting with Caltex in 1954, he spent several months in India getting first-hand knowledge of the area to which he is now assigned.

Dittus, who started with SOCAL in 1916, has supervised construction in all parts of the world. In Europe, from 1935 to 1937, he was in charge of procuring materials for the construction of the Bahrain refinery.

Otmar E. Teichmann, associate manager of the Heat-Power Research department at Illinois Institute of Technology's Armour Research Institute, has been elevated to manager of the department. He succeeds **Wilson P. Green,** who resigned.

Teichmann joined the foundation as a research engineer in 1942 and three years later, became supervisor of fluid mechanics in the Heat-Power Research department. He was made associate manager in 1953. Teichmann previously had served a Vienna power company as research engineer and worked as design engineer for Burke and James, Inc., in Chicago.

Lonnie W. Vernon has been promoted to senior research chemist in the Research and Development division at Humble Oil & Refining Company's Baytown, Texas, refinery. Also advanced to senior research chemist in that division is **E. L. Gunn.**

Gunn's research is in emission spectroscopy, X-ray diffraction and X-ray fluorescence, concerned primarily with the elucidation of the composition and structure of catalytic materials. Dr. Vernon will assume principal responsibility for Humble's catalytic property research.

Dr. Vernon holds bachelor's and master's degrees in chemistry and a doctor's degree in physical chemistry from Rice Institute. Gunn is a chemistry graduate from the University of Texas, where he also received a master's degree in psychology.

Russell L. Maycock, formerly assistant manager of the Physical Chemistry department at Shell Development Company's research center in Emeryville, Calif., has replaced **John Anderson** as director of Shell Chemical Corporation's Houston research laboratory. Anderson was named director of the research facilities at Shell's synthetic-rubber plant in Torrance, Calif.

Dr. Maycock, who has been assistant manager of the Physical Chemistry department since 1952, joined Shell Development as a laboratory assistant at Emeryville and since has served in increasingly responsible positions, all in the research field at Emeryville. A University of California graduate, he completed his doctorate at the University of Illinois.

Robert E. Mays, for two years assistant manager of the Comptroller's department of Creole Petroleum Corporation, has been named manager of a new Budget department. At the same time, the company's Economics department was reorganized.

H. Donald Schersten, who was procedures, statistics and auditing coordinator, is taking Mays' place in the Comptroller's department. He, in turn, will be succeeded by **Jack F. Holmes.**

The new Budget department will advise in the coordination and evaluation of the company's budget, permitting the Eco-

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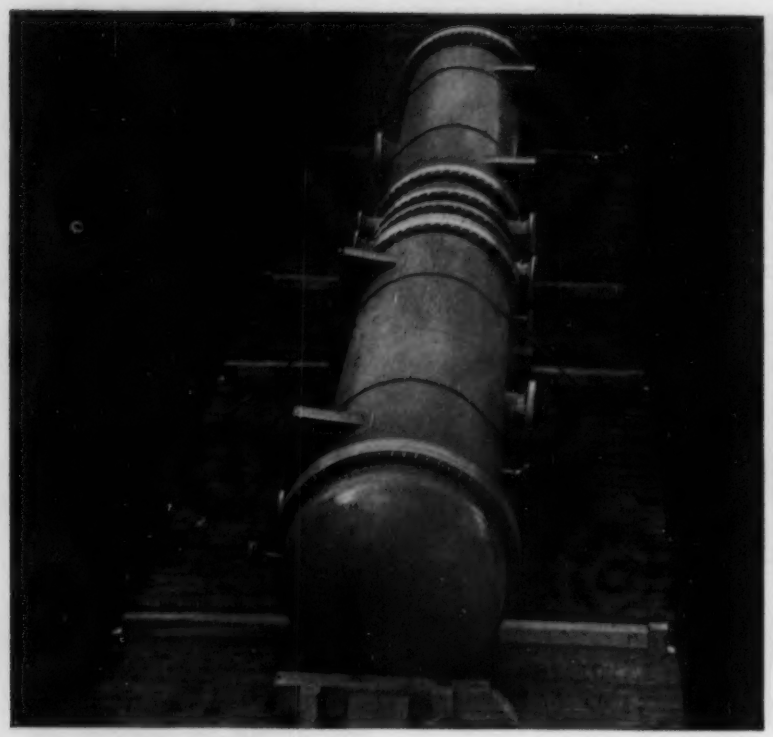

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Supersonic testing...centrifugal casting...stress-relieved welding of Ampco 8...are some of the advanced techniques specified by Downingtown engineers in designing these two 42″ x 16′ inside floating head propane condensers. Essential cost savings resulted, and the condensers are highly corrosion-resistant.

Units meet ASME Code and TEMA Class R requirements in every respect. Ampco 8 was used extensively because of its higher allowable design stresses at elevated temperatures. Design pressure is 275 psi on the shell side and 100 psi on the tube side.

Each unit has 1320 Cupro-Nickel tubes ¾″ O.D. x 16′ 0″ long. Tube sheets are of Ampco 8. The channel—a centrifugal casting of Ampco 8—was supersonically tested to assure soundness. Channel cover is of Ampco 8 lined steel. Shell and shell cover are of ¾″ carbon steel. Inside floating head is a centrifugally cast Ampco 8 flange welded to a 40″ I.D. x ¾″ Ampco 8 head. All Ampco 8 weldments were heat-treated after welding to increase resistance to corrosion by relieving internal stresses set up during welding.

Write for further information on Downingtown experience in designing and fabricating heat exchangers and other pressure vessels for the refinery. Heat treating and X-ray testing as required by specifications.

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What's Happening...

nomics department to intensify studies and analyses of petroleum economics. The department will be called the Department of Petroleum Economics.

Mays, who previously had been with Standard Oil Company of California, joined Creole in 1949 as an accountant, and in 1951 was appointed coordinator for the Comptroller's department. He was promoted to assistant comptroller and assistant manager of the department in June, 1953.

William C. Foster, former Deputy Secretary of Defense and president of the Manufacturing Chemists' Association, has become an executive vice president of Olin Mathieson Chemical Corporation. He headquarters in the company's New York offices.

Foster

Foster had completed nearly 11 years of government service when he resigned his Defense post in January 1953, to become MCA's first full-time president. Previously, he served as head of the Marshall Plan with Cabinet rank and title of Administrator for Economic Cooperation; Under Secretary of Commerce; deputy U. S. Special representative in Europe for ECA, with rank of Ambassador, and deputy administrator of ECA.

During World War II, he held various positions, concluding as director of the Army Service Forces' Purchases division.

John F. Horner, a chemical engineer with American Oil Company in Texas City, Texas, has been promoted to head of the Process Design Section of the Research and Development department. Also receiving a promotion in the Process Design section was **E. J. Stanton,** a chemical engineer with the company since 1941.

For the past year, Dr. Horner has been serving as a group leader handling process design work for Amoco's new Yorktown, Va., refinery. He joined the company's technical staff in 1949.

Charles E. Lapple, former associate professor of chemical engineering at Ohio State University, has joined the Physical Sciences division of Stanford Research Institute. As a senior scientist, he will take charge of research in fine-particles technology and chemical engineering.

Lapple is a specialist in dust and fume collection, in abatement of atmospheric pollution, particle sizing and the handling of fluids. One time with E. I. Du Pont de Nemours and Company's Engineering Research laboratory in Wilmington, Del., he has served the past five years as a consultant to industry as well as a teacher.

Jack C. H. Stearns, with the Dow export companies for the past year and a member of the export board of directors, has been elected to a newly-created post as executive vice president of Dow Chemical International, Ltd., and Dow Chemical Inter-American, Ltd.

Stearns started with Dow in 1937. He was appointed to an executive position

with the Dow export companies in July 1954 and elected to the export board of directors in December.

Sam R. Bethea has been promoted to research specialist in the Research and Development division at Humble Oil & Refining Company's Baytown, Texas, refinery. He holds B.S. and M.S. degrees in chemical engineering from Rice Institute. In his new position, he will specialize in the development of new catalytic processes.

Deaths:

William H. Atcheson, Tulsa advertising manager for The Gulf Publishing Company, was killed in Kansas City August 14, when he was hit by the propeller of an airliner. He was 49 years old.

W. H. Atcheson

Atcheson had debarked from a Minneapolis-bound plane a few minutes before his death. Apparently mistaking a departing plane for his scheduled flight, he dashed across the field and into the path of the taxiing airliner.

A veteran of 34 years with the company, he started as an office boy in the Houston office when he was 15 years old. He later saw service in the Printing Sales and Advertising departments, transferring to Tulsa in 1947 as district advertising manager.

O. D. Robinson, chairman of Republic Oil Refining Company, died August 19 at Corapolis, Pa. He was 69 years old.

William J. Hale, scientist with The Dow Chemical Company since 1917, died August 8 at Midland, Mich. He was 79 years old.

Dr. Hale established the company's Organic Research Laboratory in 1919, and served as its director until 1935 when he was named a research consultant. His outstanding development work included processes to increase production of chloracetic acid and phenyl ethyl alcohol, and he helped develop the chlorobenzene process for producing phenol. He was author of nine books and held 45 patents.

Robert J. Crawford, manager of the Refinery Accounting department of Sun Oil Company, died August 20 while on vacation at Eagles Mere, Pa. He was 46 years old.

Bernard W. Anthony, secretary and treasurer of Oronite Chemical Company, died August 3 at Lafayette, Calif. He had been under treatment for a heart ailment for several months. Oronite is a subsidiary of Standard Oil Company of California.

Edgar M. Clark, former vice president of Standard Oil Company (New Jersey) and co-inventor of the first successful oil-cracking process, died July 31 at Phoenix, Ariz. He was 88 years old. Clark aided in the invention of the Burton pressure still, a process which in 1913 ended the threatened shortage of gasoline and revolutionized refinery processes.

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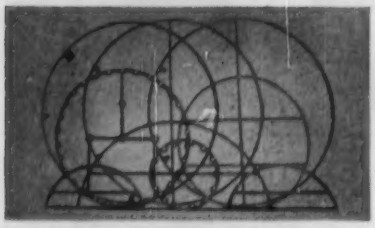

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Heard at Meetings . . .

A. I. E. E. in Houston

The petroleum industry trend today is toward total purchased electric power when a reliable source is available, it was reported at the Petroleum Technical Conference of the American Institute of Electrical Engineers in Houston by W. E. Highfill, Esso Research and Engineering Company, Linden, N. J.

With expansion of the industry in 1950, electric power requirements have increased to the point where additional electrical power is required and refinery generated power is inadequate for present day needs, leading to purchase of outside power, he pointed out.

"Today, where reliable electric power is available, the petroleum industry trend is toward total purchased power with load center substations being required to receive and distribute the power," Mr. Highfill said.

"Many petroleum refineries may be faced with increased power requirements in the near future," he said and as maximum demand increases, so does optimum distribution voltage and the required short circuit level. When these exceed the maximum ratings of 15 kv or 500 mva, available in standard metal-clad switchgear, station type cubicle switchgear offers the following advantages over the conventional open switchyard with oil circuit breakers:

- Compact construction for indoor or outdoor installations.
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A. S. M. E. in New Orleans

American Society of Mechanical Engineers will hold its tenth annual Petroleum Engineering Conference September 25-28 at the Roosevelt Hotel in New Orleans. The conference will be sponsored by the society's Petroleum division, with the cooperation of the New Orleans section.

The Petroleum division is divided into operating groups, each group specializing in a certain phase of the petroleum industry. These are the Manufacturers, Materials, Production, Refining and Transportation Committees. During the Conference there will be 32 technical papers and three panel discussions presented covering the activities represented by these groups.

The conference dates do not include the all day inspection trip which has been purposely arranged for September 29 so as not to conflict with the technical sessions. Registration will start Sunday afternoon, September 25, on the mezzanine floor at the Roosevelt Hotel. Sunday evening there will be a "Get Acquainted" reception in the Gold Room. Refreshments and showing of color films of New Orleans and Louisiana. The New Orleans section will act as host.

Technical sessions will open Monday morning, September 26 at 9:00 a.m. There will be four sessions, Refining, Production, Transportation and Materials. The Welcoming Luncheon will be at noon with Walter J. Verlander, chairman of the New Orleans section, presiding. Waldemar S. Nelson, chairman of the Local Arrangements committee, will make the introductions, and David W. R. Morgan, president of ASME, will make the address.

Afternoon sessions will start at 2:00 p.m. and continue until 4:00 p.m. One of the afternoon sessions will be a panel discussion of "Mechanics of Bulk Oil Measurement." At 4:00 p.m. the Transportation, Manufacturers and Production Operating committee will meet. The New Orleans section will be host at a cocktail party at the Engineers Club from 5:00 to 7:00 p.m. All registrants and their ladies are invited.

Tuesday, September 27, will be a full day of technical sessions starting at 9 a.m. Industry luncheons for the Refining, Transportation and Production groups will be at 12:00 noon. Every person attending the conference is invited to attend one of these luncheons. Tuesday afternoon sessions will start at 2:00 p.m. Another panel discussion will be held on "A.S.M.E.

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FIG. 29 Cylinder with Impeller

FIG. 17-28 Cylinder

FIG. 215 Flanged

FIG. E-57 Double Window

FIG. 212 Visibility Welding Neck or Screw

FIG. E-811 Flapper

FIG. E-1810 Rotating Wheel Type

All sizes up to 6" *Send for Catalog*

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DOMESTIC EXPORT

LABORATORY APPARATUS & CHEMICALS

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Who's Meeting . . .

Unfired Pressure Vessel Code."

Tuesday evening will be the banquet preceded by a social hour starting at 6:00 p.m. Waldemar S. Nelson, New Orleans general chairman of Local Arrangements committee, will preside. P. E. Frank, New York chairman of Petroleum division, will present awards.

Sessions will open again Wednesday at 9:00 a.m. and continue until noon. Afternoon session will start at 2:00 p.m. and will include a panel discussion of "ASA B31 Piping Code." This will conclude the technical sessions of the conference.

Thursday, September 29, will be devoted to inspection trips. Busses will leave the hotel at 9:00 a.m. and drive up to the Shell Oil refinery at Norco. The tour will then proceed to Reserve, La., for luncheon. The return trip will be along the old River Road next to the Mississippi River levee. Some of the old plantation homes are along this route, including the plantation house at San Francisco Plantation made prominent in Mrs. Frances Parkinson Keyes' novel "Steamboat Gothic." A program for the visiting ladies has been arranged by the ladies of the New Orleans section. Monday, September 26, a luncheon will be held at Brennan's Restaurant, followed by a walking tour of the French Quarter.

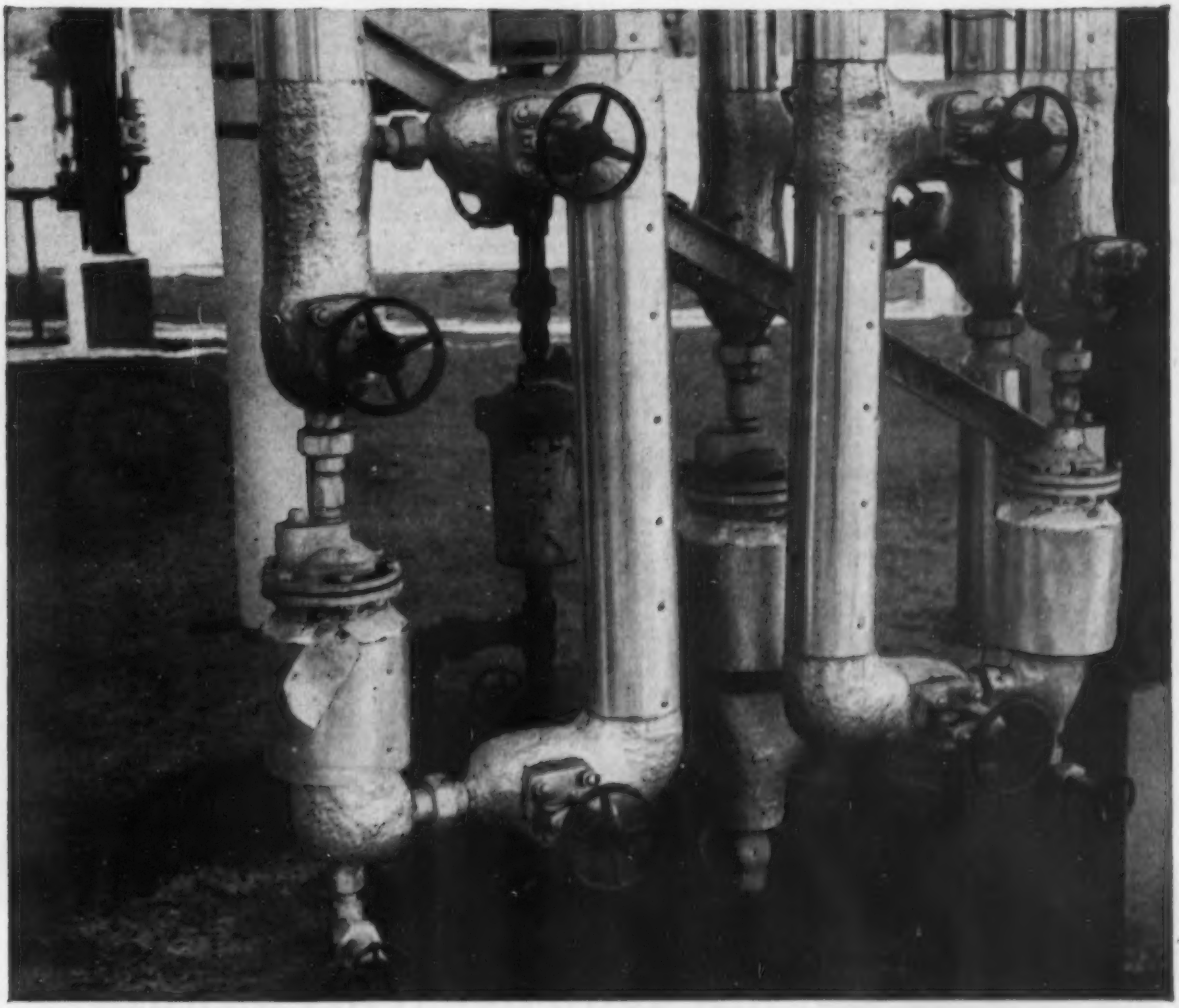
A. I. Ch. E. in Galveston

The tenth annual technical meeting of the South Texas Section of the American Institute of Chemical Engineers will be held October 14 at the Hotel Galvez in Galveston, Texas.

A symposium on Air and Stream Pollution will be presented in the morning concurrently with a general technical session. The Air and Stream Pollution symposium will include discussions by experts from each of the three main types of organizations concerned with this topic: industry, public enforcement agencies and scientific foundations. The General Session will include papers on "Condensation of Vapors Inside Tubes," "Fuel Requirements of Tomorrow's Engines," "Chemical Treatment of Natural Fibers," and "Using the Epoxy Resin." A symposium on Operations Research will be offered in the afternoon.

MEETINGS CALENDAR

SEPT. 14–16	National Petroleum Association (Annual Meeting), Traymore Hotel, Atlantic City, N.J.
22–23	Chemical Market Research Association, Cavalier Hotel, Virginia Beach, Va.
22–23	Western Petroleum Refiners Association (Regional Technical-Industrial Relations Meeting), Hotel Henning, Casper, Wyo.
22–23	Mid-Continental Oil & Gas Association, Louisiana-Arkansas Division (Annual Meeting), Roosevelt Hotel, New Orleans.
25–28	American Institute of Chemical Engineers, Lake Placid Club, Lake Placid, N.Y.
25–28	American Society of Mechanical Engineers (1955 Petroleum Mechanical Engineering Conference), Roosevelt Hotel, New Orleans.
25–30	International Gas Union (Annual Meeting), Hotel New Yorker, New York.
29	Natural Gasoline Association of America, (Oklahoma Regional Meeting), Skirvin Hotel, Oklahoma City.
OCT. 2– 6	American Society for Testing Materials Committee D-2, Petroleum Products and Lubricants, Statler Hotel, Washington, D.C.
3– 7	American Institute of Electrical Engineers (Fall General Meeting), Morrison Hotel, Chicago.
10–12	American Society of Mechanical Engineers, Lubrication Activities Committee, and American Society of Lubrication Engineers (Joint Lubrication Conference), Antlers Hotel, Indianapolis, Ind.
10–12	American Oil Chemists Society (Fall Meeting), Bellevue-Stratford Hotel, Philadelphia, Pa.
11–15	Society of Automotive Engineers, Statler Hotel, Los Angeles, Calif.
12–14	National Association of Corrosion Engineers, Permian Basin Section, (Biennial Permian Basin Corrosion Tour), Headquarters at Lincoln Hotel, Odessa, Texas.
13–14	California Natural Gasoline Association (Annual Fall Meeting), Ambassador Hotel, Los Angeles.
14	American Institute of Chemical Engineers, South Texas Section, (Annual Technical Meeting), Galvez Hotel, Galveston, Texas.
17–19	American Gas Association (Annual Convention), Los Angeles.
18–20	American Institute of Electrical Engineers (Motor Applications and Problems in Heating and Cooling Conference), St. Louis.
18–21	National Association of Corrosion Engineers (South Central Regional Meeting), Shamrock-Hilton Hotel, Houston.
18–22	National Safety Council (National Safety Congress and Exposition), Chicago.
18–22	National Safety Congress & Exposition, Sponsored by National Safety Council, Chicago.
20	American Institute of Chemical Engineers, New York Section, Hotel Statler, New York.
20–21	Western Petroleum Refiners Association (Regional Technical-Industrial Relations Meeting, Garrett Hotel, El Dorado, Ark.
24–26	American Standards Association (Annual Meeting), Sheraton Park Hotel, Washington, D.C.
24–28	American Society of Civil Engineers (Annual Convention), Statler Hotel, New York.
27–29	Rocky Mountain Oil & Gas Association (Annual Convention), Cosmopolitan Hotel, Denver, Colo.
28	Natural Gasoline Association of America (Southern Regional Meeting), Captain Shreve Hotel, Shreveport, Louisiana.
31–Nov. 2	Society of Automotive Engineers (Transportation Meeting), Chase Hotel, St. Louis, Mo.
31–Nov. 2	National Lubricating Grease Institute (Annual Meeting), Edgewater Beach Hotel, Chicago.
NOV. 3– 4	Annual Instrumentation Conference, Sponsored by School of Engineering, Louisiana Polytechnic Institute, Ruston, La.



Picture of Low Cost Steam Trapping . . .

The Armstrong steam traps pictured above are in a field processing plant in Oklahoma. It's a nice installation —traps neatly installed in bypasses, lines well insulated, blowdown valve below each trap. Obviously, no corners have been cut to save nickels. Then, what do we mean by "picture of *low cost* steam trapping." Simply this:

Low cost traps—the price tag doesn't read any lower, but, because of high capacity, you can usually select an Armstrong trap one size smaller than other makes.

Low cost installation — Armstrong offers a choice of either side inlet-side outlet or bottom inlet-top outlet traps in most sizes so that hook-ups can be made with a minimum of labor and fittings. All traps can be equipped with internal check valves, and the three smallest traps are available in integral strainer style. These optional built-in features mean lower installation costs.

Low cost maintenance—Armstrong traps last for long periods without repairs because the valves and seats are corrosion-resistant, file-hard chrome steel, ground and then lapped together; and all other working parts are corrosion-resistant stainless steel. Materials and workmanship are unconditionally guaranteed.

Low production costs—because Armstrong traps provide fast drainage and have large air handling capacity, they provide maximum output from steam heated units and give a bigger return on equipment investment. They save steam, too, through reduction of non-productive radiation losses and freedom from leakage. For *low cost* trapping it pays to specify "traps shall be Armstrong."

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Reviewing New Books . . .

Basic Lubrication Practice, by Allen F. Brewer. This volume contains the information needed to choose and use the most effective lubricant for industrial and power plant machinery. Numerous charts and tables make quick comparisons of lubricants for specific machinery under various operating conditions.

Special features include complete coverage of lubricants, dual viscosity figures (Centistokes and Saybolt) and many literature references.

This book will be useful to anyone concerned with lubrication as a major factor in plant operation. Lubrication and maintenance engineers, executives, purchasing agents and machine operators will find this information of value in keeping output up and maintenance costs down.

(Reinhold Publishing Corporation, 430 Park Avenue, New York 22, 282 pages, $6.75.)

Infrared: A Library of Congress Bibliography. Compiled by the Library of Congress under a contract with the Office of Naval Research, this bibliography includes all references to published literature on the subject of infrared radiation from 1935 to 1951. The references were found by a systematic search of available sources.

The classification proceeds from infrared theory and general infrared-optical properties through the various elements and components of infrared equipment, infrared photography and spectroscopy, to its various applications in science, industry and technology.

(Office of Technical Services, Department of Commerce, Washington 25, 374 pages, $3.)

Ignition Studies, Part IV, Relation of Minimum Ignition Point to Other Ignition Phenomena, prepared by the Naval Research Laboratory. To achieve a better understanding of the relationship between fuel composition and ignition properties, and to develop a simple and rapid method of testing small quantities of fuels, additives, pure hydrocarbons and other compounds, the Naval Research Laboratory conducted a series of experiments, reported in four volumes.

This, the fourth work, was spurred by the rapidly increasing use of high-quality fuel and distillate stocks in jet aircraft, home burners, and other equipment, in competition with the Navy's need for large quantities of diesel fuel, or suitable substitutes, for the fleet. The purpose of these studies is to investigate the possibility of bolstering the supply of high cetane straight-run fuel by the use of low cetane fuels. Numerous methods of evaluating ignition behavior were tried out, and a controlled ignition meter was developed especially for the tests.

Among the subjects investigated were the ignition behavior of individual pure hydrocarbons; the behavior of ignition improvers in pure form and in mixture with pure hydrocarbons; the relationships between ignition point, cetane number and ignition delay; the effect of temperature and oxygen percent on ignition, and characteristic minimum ignition points of isomeric hexanes.

(Office of Technical Services, Department of Commerce, Washington 25, 15 pages, 50 cents.)

Oil Industry Background Information Bulletin, No. 11, prepared by API Department of Information. This study, which required more than two years to complete, discloses that the U. S. oil industry makes more than 2347 different products.

A chart in the booklet shows how petroleum products reach each home and industry. In addition, it contains a discussion of the uses of petroleum products, and what they contribute to the comfort, convenience, security and economic advancement of the American people.

In this study, a "product" is defined as any article manufactured by an oil company according to a unique and specific formula. Articles of secondary manufacture—such as the thousands of end products indirectly produced from petrochemicals—are excluded.

NUMBER OF PRODUCTS
Made by
THE U. S. PETROLEUM INDUSTRY

Class of Product		Number of Products
Fuel gas		1
Liquefied gases		13
Gasolines:		40
Motor	19	
Aviation	9	
Other (tractor, etc.)	12	
Gas Turbine (jet) Fuels		5
Kerosines		10
Distillates (diesel fuels, and light heating oils)		27
Lubricating oils (light and heavy), compounded and uncompounded)		1,156
White Oils		100
U.S.P.	78	
Technical	22	
Rust Preventives		65
Transformer and cable oils		12
Greases		271
Waxes (Crystalline and microcrystalline)		113
Residual fuel oils		16
Asphalts (including road oils, tars, etc.)		209
Cokes		4
Carbon blacks		5
Chemicals and Other*		300

* Solvents are among the "Other" products.

In its discussion of light distillates, the book points out that the best-known products in the group are gasolines. It lists the production of gasoline alone as amounting to 1250 million barrels a year, and representing 40 distinct types, each designed to do a specific job.

These 40 basic types do not include consideration of competitive formulas of the thousands of oil companies in the U. S.

(Department of Information, 50 West 50th Street, New York 20. Single copies may be obtained free, or bulk orders may be purchased at $5 a hundred.)

Information Processing Equipment, by M. P. Doss. All the equipment used in the preparation, reproduction and utilization of written information are described and illustrated in this book. How to process information or data from any source; how to handle it, and how to store it will prove a blessing to those seeking solutions to problems involved in today's mountain of paper work.

Full chapters, written by experts, cover the latest developments in such information media as electric and automatic type-

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New Books . . .

writers, calculating machines, stencil and hectographing equipment, collating machines, lensless copying with sensitized paper, industrial photography, microcopying, letterpress and offset printing, dictating and recording machines, punched cards, machines for handling numerical data and others.

This is the first book ever published to include such a range of data on the subject. The idea for the book was conceived as a result of the reception to the symposium on this subject sponsored by the ACS's Division of Chemical Literature.

(Reinhold Publishing Corporation, 430 Park Avenue, New York 22, 270 pages, $8.75.)

Symposium on Radioactivity, Special Technical Publication 159, American Society for Testing Materials. This symposium, the first to be sponsored by the ASTM Committee on Radioactive Isotopes, calls attention to the possible utilization of radioactive isotopes in testing. The symposium is an effort to develop information for those in a position to put it to practical use.

There are six papers included in the symposium, in addition to a foreword and introduction written by S. Edward Eaton. The papers are "Properties and Uses of Radioisotopes," by G. D. Calkins; "Applications of Radioactive Measurements to ASTM Work," by O. M. Elliott and J. L. Kuranz; "Design of Radioisotope Laboratories for Low and Intermediate Levels of Activity," G. G. Manov and O. M. Bizzell; "Training Personnel in Radioisotope Techniques," Donald R. Smith; "Nuclear Radiation—Its Detection and Measurement," Ernest H. Wakefield, and "Management Problems Resulting from Radioisotope Utilization by Industry," W. L. Davidson. (American Society for Testing Materials, 1916 Race Street, Philadelphia 3, 54 pages, $1.75.)

Techniques of Plant Maintenance —1955. This book is made up of the papers along with the discussions at the Plant Maintenance and Engineering Show (January, 1955) and includes reports of the round table sessions at which specialized phases of the maintenance function were given intensive consideration.

Typical general sessions were on "What Management Wants from Maintenance and What Maintenance Wants from Management", "Planning and Scheduling," and "Managing the Maintenance Organization." Typical sectional conferences: Standardization and Work Measurement," "Maintenance Cost Control," and "Preventive Maintenance within Balanced Maintenance."

The conference covers industries horizontally so many are the papers by experts outside the process industry. Annual volumes of this conference for the years 1951, 1952, 1953 and 1954 also are available. 218 pages.

(Clapp & Poliak, Inc., 341 Madison Avenue, New York 17, $7.50).

Education in Petroleum Engineering and the Petroleum Sciences in the South, prepared by the Regional committee on the Petroleum Sciences, Southern Regional Education Board. This brochure outlines ways of obtaining undergraduate and graduate education in petroleum engineering and the petroleum sciences at Southern universities which have developed specialized curricula in the fields.

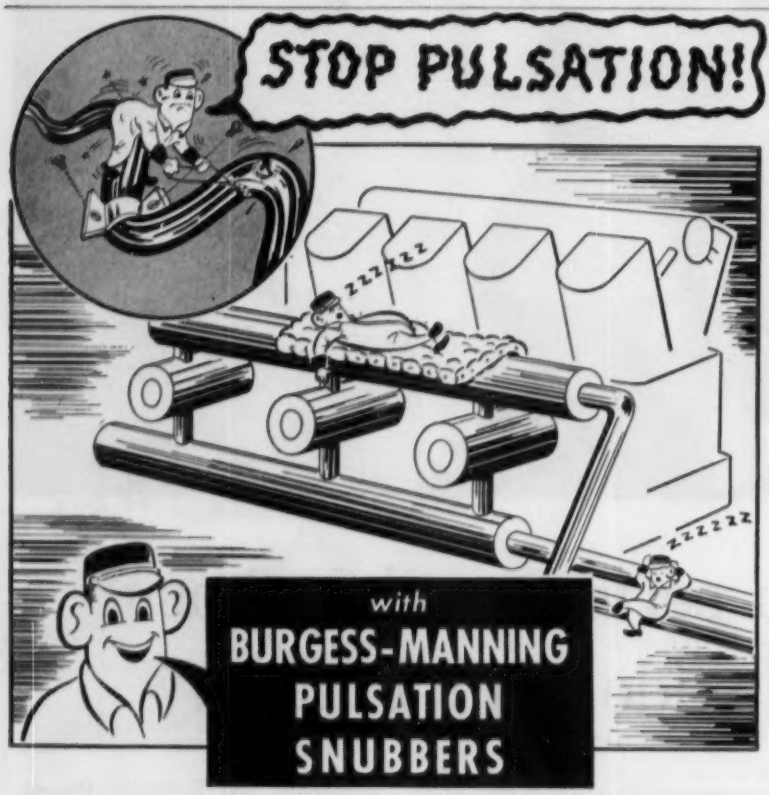
Seven universities have joined in planning their programs to offer more adequate service to the South. The cooperating institutions are Texas A&M College, Louisiana State University, Texas Technological College and the universities of Texas, Oklahoma and Tulsa.

These schools are described as having made arrangements for students to take most of their first two years undergraduate work at other institutions, transfer at the end of their sophomore year and complete requirements for a bachelor's degree in petroleum engineering in the same time as non-transfer students.

The institutions also have agreed that students from other schools may enroll for graduate work in petroleum engineering or one of the petroleum sciences on the same basis as students moving directly from undergraduate to graduate work at the same institution. (Southern Regional Education Board, 830 West Peachtree Street, Atlanta, Ga., 13 pp.)

An Evaluation of Corrosion Inhibitors for Use in Aircraft Fuels. Thirty-two products have been tested by the Navy for their suitability as anti-corrosion additives in aviation fuels. Results of the tests are available in this research report.

The Naval Research Laboratory found that the incorporation of oil-soluble corrosion inhibitors directly into fuels at the time of manufacture is the best methods of protecting transport pipe lines and other



Burgess-Manning Pulsation Snubbers will remove one of your most aggravating and costly bug-a-boos, that of line surges from compressors, pumps, blowers, etc. Maintenance and service costs will drop sharply — lines and associated equipment will operate at a new efficiency — flow control can be greatly improved. Structural supports of pipe lines need no longer be of costly and special construction — gas compressors and pumps will deliver full design flow with greatest efficiency in pulse-free piping.

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Moisture-resistant. K&M Apac sheets are used on the ceiling of this toll entrance and custom office inspection enclosure at the Port Huron, Michigan, Blue Water International Bridge. The moisture in the air at the bridge won't harm them.

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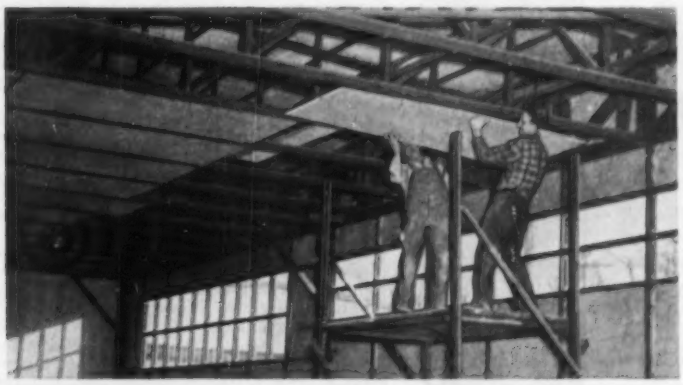
Remarkable economy!

Temperature, humidity safeguards. Walls of K&M Apac sheets give dependable aid to a cigar manufacturer in an important process—where temperature and humidity are accurately controlled.



All-purpose sheets. This photo shows K&M Apac sheets being applied on a building where they are used for both outside and inside walls as well as for ceilings.

You'll find a thousand and one uses for these flat asbestos-cement sheets: as an interior and exterior siding, office paneling, plant and office ceilings, machine shop sheathing, stock room sidewalls, basement partitions, linings for elevator casings. Use them almost everywhere, inside and outside.

Built to last. K&M Apac sheets are made of two practically indestructible materials, asbestos fiber and portland cement. They won't burn, rot, or corrode. And they never need protective paint.

Look over the illustrations. See a few of the many places where Apac sheets are applied. Then contact your K&M distributor, and ask him to tell you more about low-cost K&M Apac sheets. Informative folders also available on request. Address inquiries to our headquarters in Ambler, Pa.

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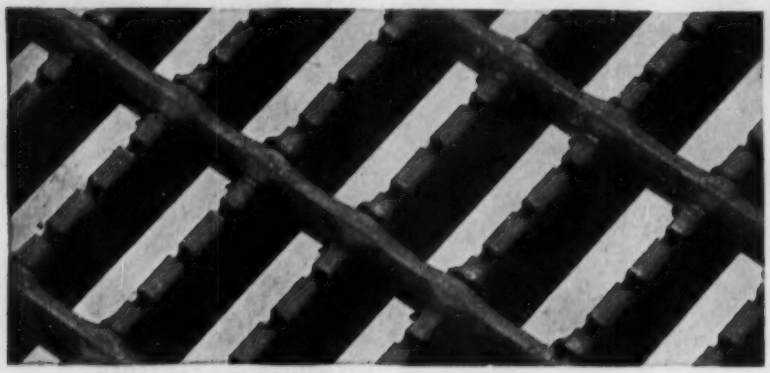

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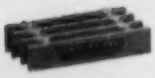

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New Books . . .

fuel-handling and storage equipment. Tests performed on the 32 available inhibitors included the determination of ferrous corrosion inhibition activity, water extractability, fuel solubility, ash content, water tolerances, and compatabilities with gum inhibitors, ignition modifiers, gasoline dyes, and other inhibitors.

Although several promising products were found, none was ideal, and it was concluded that choice of inhibitors must be based on a compromise after evaluation of the relative significance of the shortcomings of the various products as tabulated in the report.

(Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., 32 pages, $1.)

Handbook of Engineering Materials, edited by Douglas F. Miner and John B. Seastone. The materials of manufacturing and construction in all branches of engineering are brought together for centralized identification and working comparison in this new source book. The handbook represents the combined resources of 51 specialists from numerous fields.

The increasing tendency for one branch of engineering to overlap with another provided the basic need and impetus for this reference work. Here, the technical properties takes precedence, with the book's emphasis on selection and use of material, and major attention directed to adaptability to fabricating methods, availability, costs, and limitations.

Arranged by classes of related or similar materials, the handbook first provides general information on specifications and standards, statistics in the application of materials, and mathematical and physical tables. The second section is devoted to metals, with details for non-metals given in the third section.

(John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, 1382 pages, $17.50.)

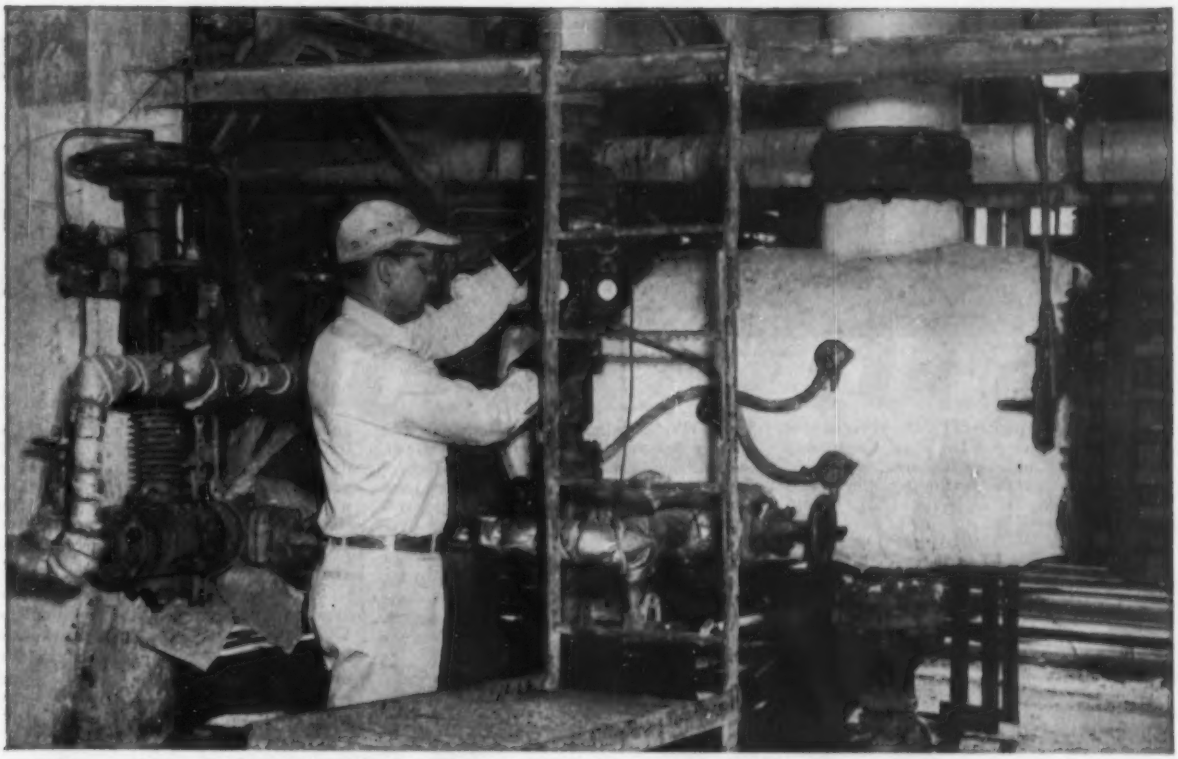
Principles of Industrial Waste Treatment, by C. Fred Gurnham. Approaching the subject from an operational or unit operations point of view, this new book deals with the sources, pollutional effects, and methods for the treatment and disposal of liquid wastes produced by industry.

Dr. Gurnham first deals with the effects of wastes on streams and sewerage systems. Following this, he examines the criteria developed by the sanitary engineer for evaluating pollution; physical, chemical, organic, and biological properties are considered separately.

The greater part of the book covers the operations and processes used to treat industrial wastes before their discharge into natural waters or municipal sewers. In the three chapters devoted to physical treatment, Dr. Gurnham analyzes sedimentation, filtration, and heat transfer operations. The four chapters on chemical treatment consider pH adjustment, oxidation and reduction, coagulation and chemical reaction, and adsorption and ion exchange.

The discussion of biological treatment includes biological filtration, activated sludge, and lagoons. Anaerobic biological treatment and miscellaneous methods are also covered. Disposal programs and brief descriptions of industries with major disposal problems conclude the volume.

(John Wiley & Sons, Inc., 440 Fifth Avenue, New York 16, 399 pages, $9.50.)



Still man checks soluble oil level in steam reboiler keg Monel-cladding of the shell, Monel in the tubes, and Monel trim on the large valve at left protect against corrosive attack of the high-temperature, aqueous HF stream.

After 13 years experience with HF alkylation, Phillips Petroleum finds that

...Monel prevents severe HF corrosion and promotes safety

In 1942, HF alkylation to produce aviation gas had "crash" priority. "Get the plant operating," was the word.

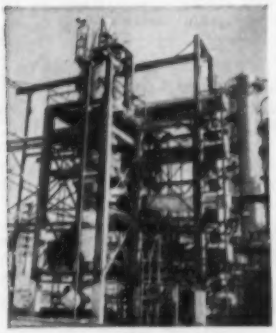
So Phillips Petroleum Company pioneered . . . built in accordance with the urgency of the times, then scheduled shutdowns at six-month intervals to check performance of materials.

What Phillips found

With high concentrations of HF at approximately atmospheric temperatures . . . and where moderate scaling can be tolerated . . . carbon steel is practical.

Where conditions are severest . . . where an extra margin of safety is needed . . . Monel® is the metal to use. With Monel in the key locations shown (see panel), Phillips has been able to stretch the interval between inspection shutdowns to two years.

Monel provides useful resistance to HF in all concentrations and (in unaerated solutions) up to 250° temperature. Raise this to 1100°F for the anhydrous acid, under certain conditions. What's more, Monel is comparatively unaffected by high stream velocities. It provides high strength and wear resistance.



Acid re-run unit regenerates HF to about 100%. See details above.

Key locations where Monel is used in Phillips HF alkylation plant at Phillips, Texas

In acid re-run unit, flash tower is constructed of Monel-Clad Steel, with Monel trays, caps and chimneys. Feed preheater contains a Monel-lined channel head and Monel tube bundle in overhead condenser and in the reboiler of the flash tower where a mixture of acid, water and oil is handled at 300°F.

Throughout the plant, critical valves, pumps and instruments are Monel or Monel trimmed. For safety, relief valves in acid-hydrocarbon service have Monel rupture discs and gaskets. Ring joint flanged acid service lines are fastened with "K"® Monel or Duranickel® stud bolts.

Are you having trouble with HF corrosion?
Write Corrosion Engineering Section,

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

Monel... *for minimum maintenance*

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Carpenter Coffy Sears Reed Monkman Hilgendorf Tuttle Hoeppner Rohland

W. Samuel Carpenter, III, has been named director of sales for **Du Pont Company's** Petroleum Chemicals division. Formerly director of manufacturing for the Cellulosics division, he succeeds **M. H. Campbell,** transferred to the new Isocyanates Sales section.

Joseph W. Coffy is head of a new department set up by **The Republic Steel Company of California,** to handle sales to the petroleum refining industry on the West Coast. He will be assisted by **Chet W. Horstmann.**

B. C. Sears, with **Cummins Engine Company** since 1946, has been appointed manager of the company's Great Lakes region, headquartered at Cleveland. He had been serving as manager of the Rocky Mountain region, stationed at Denver.

James W. Reed, vice president of **The Cooper-Bessemer Corporation,** has been made Pacific Coast manager, in charge of the company's Los Angeles offices. **John Roger,** who held this post for 15 years, was named special representative and consultant.

Forest C. Monkman, Jr., a specialist in metals testing and research, heads a new research division set up by **Walworth Company,** to develop valves and fittings for use in nuclear power systems.

Karl K. Hilgendorf, formerly with Allis-Chalmers Manufacturing Company and Johnson Service Company, has been selected as advertising manager for **Cleaver-Brooks Company.** He will handle all nation-wide advertising for the company's four divisions.

John R. Tuttle, former vice president and treasurer of **Crouse-Hinds Company,** has become president and chairman of the board, succeeding three company officials who retired. They are **William L. Hinds,** chairman; **Albert F. Hills,** president, and **W. C. Blanding,** executive vice president.

C. Scott Hoeppner has been named branch manager for **Peerless Pump division, Food Machinery and Chemical Corporation.** With the company's sales engineering force since 1948, he now heads a new factory sales office in San Francisco.

George W. Rohland, Jr., has been named oil-field equipment sales manager in the Lafayette, La., area by **Delta Tank Manufacturing Company, Inc.**

Bennett Robinson Gilligan Coerper Kraemer Pape King Schreiner Weston

Gale W. Bennett has been appointed a fractories engineer by **Norton Company.** He will be assigned to the sales territory including eastern Pennsylvania, lower New Jersey and all of Maryland, Virginia, North and South Carolina. He succeeds **Norman K. Russell** who resigned.

W. C. Robinson, with **Tube Turns** since 1944, has been made an assistant sales manager and will take part in the sales promotion programs for the company's Eastern division territories.

Bernard F. Gilligan, a project manager for **Foster Wheeler Corporation,** has been named sales manager for the Gulf Coast district of the company's Process Plants division. He will headquarter in Houston and handle sales of refinery and chemical processes in that area.

Philip R. Coerper, formerly with Wisconsin Axle division of Rockwell Spring and Axle Company, now is sales engineer for **Nordberg Manufacturing Company.** Assigned to the Power Chief Engine department, he will make his headquarters in the company's main office at Milwaukee.

W. H. Kraemer, with **The Cooper-Bessemer Corporation** at San Francisco since 1950, has been assigned to the branch office in Los Angeles. He is responsible for the application of engine-driven compressors on pipeline operations in refineries and petrochemical plants.

Stan Pape is now head of research for **Sharp Chemical Company.** His work in the company's Houston laboratory will consist of formulating and developing the production line of oil-field treating chemicals.

James R. King has been appointed manager of market development for the Chemicals department of **The Quaker Oats Company.** He will be responsible for establishing new industrial products and creating new markets for existing industrial products.

Max Schreiner, recently retired from the Navy as a captain, is now executive engineer with **Elliott Company.** He is in charge of all engineering turbine, compressor, supercharger and general apparatus divisions.

Roy E. Weston, formerly sanitary engineer for The Atlantic Refining Company, will devote full time to his consulting firm, **Weston, Eckenfelder and Associates.** For the past 16 years, he has been in charge of Atlantic's waste-control program, including surveys, research, development, process engineering and operation.

Henry J. Kaiser Company has made **T. A. Bedford,** an executive with various Kaiser-affiliated companies for the past 23 years, a vice president of the Kaiser Engineers division. He formerly was vice president and director of Kaiser Motors Corporation and Willys Motors, Inc.

He joined the Kaiser organization in 1932 during the construction of Hoover Dam on the Colorado River, and subsequently participated in building Grand Coulee Dam spanning the Columbia River. During World War II, he was active in

kaiser engineers *will design and construct your new*

fluid coker

Kaiser Engineers, designers and builders for the petroleum industry, has been appointed by Esso Research and Engineering Company to design and construct Fluid Coking Units for its licensees.

plus

Not only is this firm qualified to engineer and build the Fluid Coker itself, but Kaiser Engineers also has the background and specialized knowledge necessary for the handling and utilization of this versatile new industrial material.

To take *full* advantage of the new Fluid Coking Process, call or write Kaiser Engineers.

kaiser | engineers ***...for low operating costs***

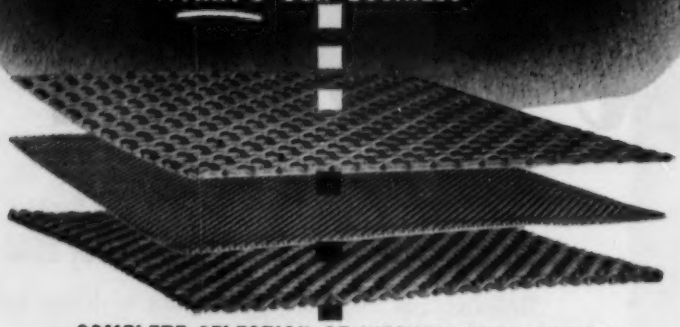
DIVISION OF | HENRY J. KAISER COMPANY

ENGINEERS CONTRACTORS

• HOME OFFICE: KAISER BUILDING, OAKLAND 12, CALIFORNIA (CABLE: KAISENGS) NEW YORK, PITTSBURGH, WASHINGTON, D. C.
• HENRY J. KAISER CONSTRUCTION CO. • HENRY J. KAISER COMPANY (Canada) LTD., MONTREAL • KAISER ENGINEERS INTERNATIONAL, INC.

For more data on advertised products, use Readers' Service Cards, last page.

Sure, we sell HOLES but our
STRAINERS & FILTERS
ARE MADE OF REAL QUALITY MATERIALS
BY MASTER CRAFTSMEN
THAT'S OUR BUSINESS



COMPLETE SELECTION OF WEAVES, SIZES, METALS

For long life and accuracy—Specify **"Cleveland."** We weave wire cloth & wire screens, we fabricate strainer and filter screens to individual job requirements. Quantities: One to One Million in all commercial metals and alloys.
We have the equipment, facilities, and experience to better serve your needs for strainer and filter elements.

WRITE FOR BULLETIN No. 7

THE CLEVELAND WIRE CLOTH & MFG. CO.
3573 E. 79th STREET • CLEVELAND 5, OHIO

Making Warm Friendships on Hot Jobs

WATER JACKETED APCO PUMP
Developed especially for the efficient handling of high temperature and highly volatile liquids. Delivers outstanding performance. Unbeatable on high head, small capacity duties.
APCO Turbine-Type PUMPS
—ideal for "1001" duties where small capacities and high heads predominate. Get acquainted.
AURORA CENTRIFUGAL PUMPS
are available in many types and sizes—all noted for their streamline coordination between impellers and shells.
AURORA Always PUMPS
We Invite Your Special Pump Problems
Write for CONDENSED CATALOG "M"

DISTRIBUTORS IN PRINCIPAL CITIES

AURORA® PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY
84 LOUCKS STREET • AURORA • ILLINOIS

Suppliers . . .

ship construction and for the past ten years had been engaged in automobile manufacturing.

Fischer & Porter Company has established a district sales office in El Paso, with **Charles Allen,** formerly a field engineer in the company's Houston office, as district manager. The district's sales territory comprises New Mexico and most of Texas west of and including San Angelo.

Feeley

Chadwick

Trinity Equipment Company, together with Industrial Corporation, has named a sales manager and a chief engineer to serve both companies. **Edward M. Feeley,** with the Trinity-Industrol organization for the past year and previously with Leeds & Northrup Company, was named to the sales management post. The new chief engineer for the two companies is **Norman H. Chadwick** who will direct research and development activities for the two companies.

Rockwell Manufacturing Company president **W. F. Rockwell, Jr.,** recently received a technical degree of industrial engineer at Pennsylvania State University. The degree was presented at the university's centennial commencement exercises.

Rockwell received the degree for a paper on "The Definition and Assignment of Executive Responsibility in the Management of a Corporation." The degree is awarded to graduates of the university's engineering school on the basis of a special thesis in the field in which they received their bachelors degrees and after experience in that field.

Condenser Service & Engineering Company has picked **George W. Nigh** as its new works manager. He formerly was with Tide Water Associated Oil Company as assistant mechanical superintendent of its Bayonne refinery, and also had served as chief engineer for several boiler manufacturers.

General Electric Company will build an apparatus-service shop in North Bergen, N. J., to provide electrical maintenance facilities for New York state and New Jersey. The new shop, to be completed in April 1956, will include more than 132,000 square feet of factory and office space, and will employ about 300 people.

United States Rubber Company has elected its executive vice president, **Gorden H. Smith,** vice chairman of the board and chairman of the executive committee. Also named to the executive committee is **Chester J. Noonan,** a vice presi-

For more data on advertised products, use Readers' Service Cards, last page.

Insul-Mastic

PROTECTIVE COATINGS
. . . the tough skin of industry

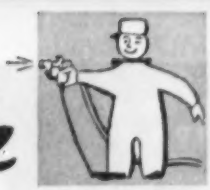
We can show you INSUL-MASTIC Coatings that have been preventing corrosion for 10, 12 and 15 years. Many of these applications are in industrial plants where corrosive fumes and vapors have been known to eat through other coatings within a very short time.

These INSUL-MASTIC Coatings have lasted through these many years without need of replacement.

This is an exceptional record. It should be considered seriously when you specify Protective Coatings.

It pays to think *first* of the coatings that *last* . . . INSUL-MASTIC.

Insul-Mastic



think first of the coatings that last!

Representatives in Principal Cities

CORPORATION OF AMERICA • 7750 West 61st Place, Summit, Illinois

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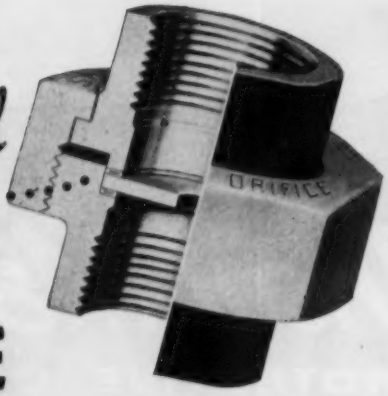
FOR THE BEST IN

Flow Control

INSIST UPON

C.M.& CO.

ORIFICE



After quick and easy installations, even in the roughest spots, these ORIFICE UNIONS will perform superbly in measuring, mixing, blending, strainer or blanking off services. Their temperature and pressure ratings are exceedingly high. They are available in forged steel, forged stainless steel and with the new tab on the orifice plate that facilitates quick identification.

OUR COMPLETE LINE OF FORGED STEEL UNIONS IS FULLY DESCRIBED IN A NEW CATALOG. WRITE FOR YOUR FREE COPY!

Clayton Mark & Company

1900 DEMPSTER STREET EVANSTON, ILLINOIS U.S.A.

THERMOCOUPLES

for every industry

DATA BOOK

New 32-page file book

★ Handily lists all data (I.S.A.) and

★ Graphically shows easiest way to select precisely the best thermocouple and protective tube for each operation.

★ Lists all components, with prices and

★ Provides handy reference for stock record.

STANDARD AND SPECIAL

For furnaces, ovens, kilns, moulding machines, pipelines, freezers, etc.

For use with all standard types of temperature indicators, controllers, recorders.

We make thermocouples from matched and checked wires to insure constant millivolt output for accurate readings. Complete selection.

FREE *write for your copy Now . . .*

WEST Instrument CORPORATION

CHICAGO

SALES OFFICES IN PRINCIPAL CITIES

Suppliers . . .

dent who has been with the company since 1919.

Smith has been with U. S. Rubber since 1917 when he joined the Planning department at the company's Detroit plant. He was elected vice president in 1945. In 1951 he became a director, vice chairman of the executive committee and executive vice president.

Noonan was made vice president and general manager of the Footwear division in 1953. In 1954 he became executive general manager of the Footwear and General Products and Mechanical Goods division. He was elected a director earlier this year.

Kreuch

Foubert

Rockwell Manufacturing Company has elected two new vice presidents. **Paul C. Kreuch,** who was assistant to the vice president of the Meter and Valve division, was advanced to vice president of the division, while **Eugene F. Foubert,** formerly manager of industrial relations, was named vice president in charge of industrial relations. Kreuch joined the company as a sales engineer in 1930. Foubert, who started with the company in 1941 as personnel manager at the Oakland, Calif., plant, was made manager of industrial relations there in 1945 and was transferred to the home office in Pittsburgh in 1947.

General Electric Company has named **Charles P. Page** as manufacturing engineering specialist for its Distribution Assemblies department. He will be responsible for forming new and revised manufacturing methods and processes involving the development of plant layout and material handling.

Page joined the company in 1953. Previous to his present assignment, he was manufacturing project engineer in the company's Trumbull Components department.

The De Laval Steam Turbine Company has chosen L. Henriques & Cia., a Guayaquil, Ecuador, firm, as its exclusive representative in that South American country. The firm will handle De Laval's line of pumps, turbines and turbine-generators, together with other products of the company.

The Dow Chemical Company has made grants to colleges and universities totaling $300,000. Allocations, made for the advancement of science and engineering at various institutions throughout the country, are for the academic year 1955-56.

A major phase of the aid-to-education program is authorization of $133,500 for distribution to 38 colleges and universities for establishment of graduate fellowships and undergraduate scholarships and to two

caustic soda—

which strength should you buy?

Here are the facts to help you decide which saves you more—50% or 73%

Can you save by switching from 50 to 73% liquid caustic? Your answer will depend on:

1. Your caustic soda freight rate.
2. Your facilities for handling caustic.
3. The amount of caustic you use.

Advantages of 73% liquid

1. With 73%, there is a substantial saving in freight charges. 63% less water is shipped per unit weight of dry caustic soda.
2. You will place fewer orders. This cuts down on your billing work.

Disadvantages of 73% liquid

1. It is priced $2.00 more per ton (dry basis) than 50% because of higher manufacturing costs.
2. If you store it as 73% liquid, you will need heated, nickel-clad steel storage tanks.
3. If you dilute 73% to 50% while unloading, you will need a cooler and other equipment. This represents a considerable investment which can be reduced if you have suitable equipment already on hand.

Use this table to see if you can save with 73%

Use the table at right to find your approximate saving on freight charges with 73% liquid caustic. The table balances two cost factors . . . lower freight charges and the higher initial price of 73% liquid caustic.

To estimate your yearly savings, multiply the figure in the right-hand column which applies to you by your annual consumption in tons (dry basis).

From these savings you will have to deduct the cost of equipment for diluting to 50% while unloading.

Freight rate per hundred weight in cents (including taxes)	*Net savings per ton (dry basis) in dollars*
5	minus 1.40
10	minus .80
15	minus .10
16	0
20	.60
25	1.20
30	1.80
35	2.40
40	3.00
45	3.70

HERE'S HELP—WITHOUT COST

You gain much by choosing the *right* strength for your conditions. In coming to a decision, why not give yourself the advantage of unbiased expert technical help? A call to your nearest Hooker sales office puts at your disposal, without obligation, the experience gained in 50 years of supplying caustic soda to industry.

Your Hooker technical service man can show you what equipment you need for converting, and help you figure your exact savings. Why not phone or write him today at the nearest Hooker office?

* * *

"CAUSTIC SODA BUYER'S GUIDE" is the title of a new pocket-size booklet we will be glad to send you. Contains helpful facts on the economics of 50% and 73% solutions; other forms of caustic soda; capacities of tank cars and other containers; useful shipping information. Write for a copy.

HOOKER CHEMICALS

4-1955

1905—Half a Century of Chemicals
From the Salt of the Earth—1955

HOOKER ELECTROCHEMICAL COMPANY

52 Forty-seventh Street, Niagara Falls, N. Y.

NIAGARA FALLS • TACOMA • MONTAGUE, MICH. • NEW YORK • CHICAGO • LOS ANGELES

For more data on advertised products, use Readers' Service Cards, last page.

LUBRICATE PLUG VALVES BETTER, SAFER, AND AS MUCH AS 20-TO-1 FASTER

. . . . with DELTA GUNS and FITTINGS

By adapting the Delta-Desco System, one man can lubricate as many as TWENTY plug valves—while by the jack screw method a man can service only ONE. The Delta-Desco System is not only faster, but easier, safer, and more positive.

The lightweight Delta Gun offers many safety features, develops 10,000 lbs. and is tested to 30,000 lbs. pressure. Delta fittings for any lubricated plug valve, guaranteed not to leak under 15,000 lbs. pressure.

Write for catalog and prices.

The Only Complete Plug Valve Lubrication Company

DELTA ENGINEERING SALES CO.
804 Louisiana Ave. Shreveport, La.
Sales Offices in All Principal Cities

DELTA-DESCO
PLUG VALVE LUBRICANTS AND EQUIPMENT

LUBRICANTS FITTINGS GUNS LUBRICATORS

Suppliers . . .

educational foundations for use in assisting deserving students.

Another part consists of $167,500 allocated to 19 institutions, most of it earmarked for unrestricted use in current expansion and operating programs. Over and above these grants, the company has allocated $140,000 for distribution to a number of schools for research on specific projects which supplement the company's own research.

Quaker Pioneer Rubber Mills, division of H. K. Porter Company, Inc., has named **James H. Joyner** manager of Pacific Coast sales. Formerly manager of the company's Los Angeles branch office, he will be in charge of sales in ten western states.

Joyner has been with Quaker Pioneer's Los Angeles office since the company was acquired by the H. K. Porter organization in 1954. He previously served Quaker Rubber Corporation as a salesman and later as manager of its St. Louis branch.

Wolverine Tube, Division of Calumet & Hecla, Inc., has named **Gerald S. Feild** as sales representative for Georgia. Formerly office sales representative at the company's Decatur, Ala., plant, he will headquarter at Atlanta.

The Foxboro Company has authorized Yokogawa Electrical Works, Ltd., to make and sell its line of instruments in Japan. The Tokyo company will manufacture the full Foxboro line, in addition to its own electrical strip chart instruments.

Groth

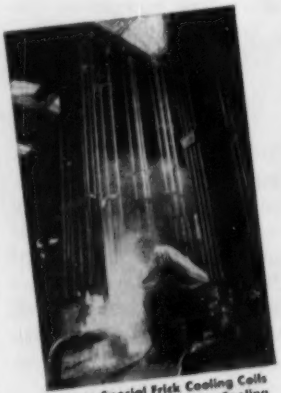
Hanlon

Farris Engineering Corporation has promoted **Edward Groth, Jr.,** to manager of its new valve-manufacturing plant in Houston. Formerly with the affiliated Farris Stacon Corporation, Groth has been with the Farris organization since 1949.

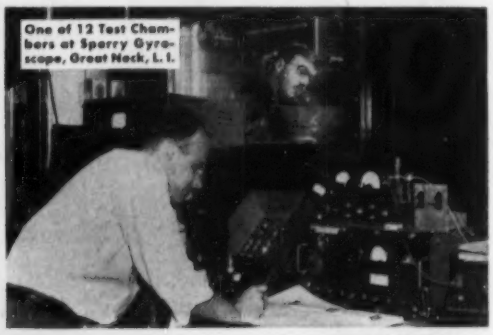
For Farris Flexible Valve Corporation, **Charles W. Hanlon** was appointed sales manager. He joins the company with 17 years' experience in the sale and manufacture of equipment for the petroleum and chemical industries on an international basis.

In addition to his duties as plant manager, Groth will have supervision over sales offices in the company's Southwest area. Two other area managers also have been named. They are **Charles S. Lewis,** headquartered in Chicago and in charge of the Mid-West area, and **Albert F. Stumm,** stationed in Philadelphia as manager for the Mid-Atlantic states.

Air Products, Inc., has released its manager of government sales, **William H. Thomas,** for assignment to the Department of Commerce's Business and Defense Services Administration. He will serve as man-



These Special Frick Cooling Coils Are Making History by Cooling Synthetic Rubber Twice as Fast



One of 12 Test Chambers at Sperry Gyroscope, Great Neck, L. I.

Need a SPECIAL Cooling System?

Then the chances are that Frick engineering and production facilities can serve you.

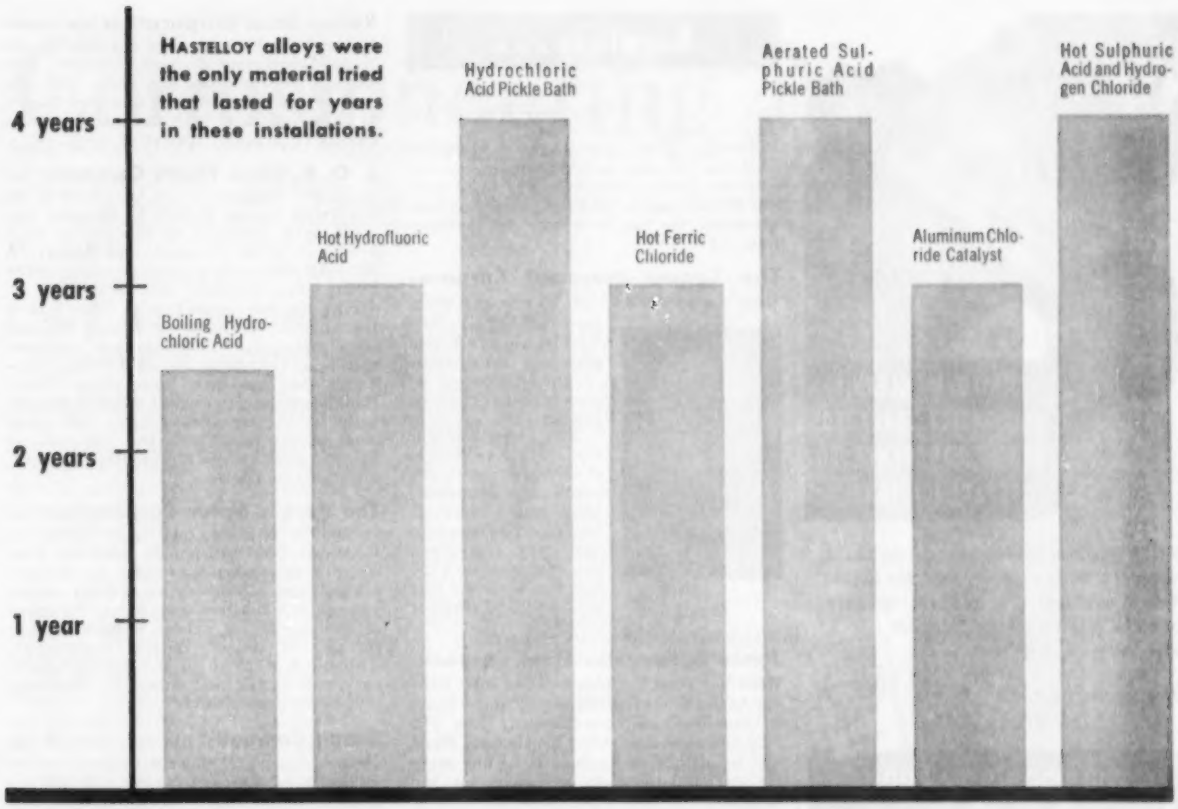
We specialize in custom-built refrigerating and air conditioning equipment: our engineers, designers, foundrymen and mechanics team up to handle those unique jobs which other manufacturers hesitate to accept.

We just furnished, for example, a 25-foot shell, over 7 feet in diameter, with complete equipment for conditioning air at 100 pounds pressure for a huge wind tunnel.

Tell us what you need—we'll do the rest! Branches and Distributors in principal cities, the world over. Write

Orange Juice is Concentrated with Frick Reversed Refrigeration at 1/10th the Cost of Steam.

DEPENDABLE REFRIGERATION SINCE 1882
FRICK CO.
WAYNESBORO, PENNA. U.S.A.


HASTELLOY alloys were the only material tried that lasted for years in these installations.
4 years
3 years
2 years
1 year
Boiling Hydrochloric Acid
Hot Hydrofluoric Acid
Hydrochloric Acid Pickle Bath
Hot Ferric Chloride
Aerated Sulphuric Acid Pickle Bath
Aluminum Chloride Catalyst
Hot Sulphuric Acid and Hydrogen Chloride

HASTELLOY Alloys *last for years under severe corrosive conditions*

These graphs were drawn from data on actual installations of HASTELLOY alloys in severe corrosive media. No other material tried lasted more than six months in most of these installations, some considerably less than this. HASTELLOY alloys lasted for years.

Use of HASTELLOY alloys saved time, money, and production time in all the installations. The graphs do not tell the entire story by any means. Some of the parts made of HASTELLOY alloys were still going strong when the data were obtained. In some, corrosion was complicated by abrasion, impact, and the presence of contaminants.

Samples for testing HASTELLOY alloys under actual operating conditions are available without obligation. Just let us know what corrosive conditions are involved. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company Office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works: Kokomo, Indiana

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Chicago · Cleveland · Detroit · Houston · Los Angeles · New York · San Francisco · Tulsa

"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation.

For more data on advertised products, use Readers' Service Cards, last page.

VICTOR alloy Studs and Bolts have met the exacting standards of the oil industry for more than 30 years. Victor is accustomed to meeting your requirements of quality, price and delivery. Try VICTOR next time you need any fastening.

Write for the new, easy to use VICTOR catalog.

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OLD SLUSH POND GETTING YOUR GAUGES?

REPAIR THEM!

Throwing away worn gauges is expensive. Save ½ to ⅔ the cost of a new one with our dependable, quality repair service. All work guaranteed. Fast return.

TULSA GAUGE AND INSTRUMENT CO.
1133 N. UTICA • TULSA, OKLA.

Suppliers . . .

ager of the administration's General Industrial Equipment division.

Thomas is on loan to the government from his company under a rotation system whereby businessmen volunteer their services for six months or longer without compensation. He has been with Air Products since 1946.

The Cooper-Bessemer Corporation has assigned **C. M. Reagle** as district manager for its New York territory. A vice president and director of the company, he also is manager of its marine sales.

Reagle

The new assignment will give Reagle close contact with the application of centrifugal and reciprocating compressors in that area. He joined the company in 1922 and was elected a vice president and director in 1925.

Jones & Laughlin Steel Corporation has added a new sales office to the operations of its Canadian subsidiary, Jones & Laughlin Steel Sales Company, Ltd. The new office, to be headed by **H. Carl King**, will be located in Regina, Sask., and serve the oil industry in Saskatchewan and southeastern Manitoba. King has been serving as the division's resident sales representative in Regina for the past year.

Solvay Process Division, Allied Chemical & Dye Corporation, has elevated **I. H. Munro** to vice president. With the company since 1935, Munro was appointed assistant chief engineer in 1945 and six years later assumed the duties of chief engineer. He had served as assistant to the executive vice president since 1953.

Tube Turns, a division of National Cylinder Gas Company, has appointed **Frank Briggs** to the staff of its Sales Development department. Briggs joined Tube Turns in 1942 and became a member of the plant's Accounting and Materials section. He was transferred to the Sales department in 1947.

Kaiser Steel Corporation has named **Kenneth V. Dawson** sales engineer in the Napa Fabricating division. Dawson, who recently retired from the Navy with the rank of rear admiral, will represent Kaiser Steel in contracts with engineers and designers on general fabricating work.

L. O. F. Glass Fibers Company has made two changes in the personnel of its Southwest region. **Robert E. Simpson** was made sales manager of the region with headquarters in Houston, and **Robert N. Heyman** was made district manager of the Dallas area.

Simpson was formerly with Glass Fibers, Inc., holding positions as Atlanta regional sales manager, Atlanta branch manager and sales representative in Detroit. Heyman, who had been with Glass Fibers, Inc., more than two years when it merged with L. O. F. Glass Fibers, had spent most of his time with the company as Southwestern sales representative, headquartered in Dallas.

The Perkin-Elmer Corporation has opened a new regional sales office in Pasadena, Calif., to handle sales and service for the company's line of process-control and laboratory equipment in the western and northwestern states. Personnel of the new office include **Winston C. Loe** for sale of process-control equipment, **Thomas A. Guerin** for the sale of laboratory instruments, and **Albert W. Ehm** who will be service engineer.

Crane Company has appointed **R. G. Hunter** district manager with headquarters in Dallas. Manager of the company's Tulsa branch office since 1946, Hunter was named to succeed **J. A. McMurry**, elevated to director and transferred to the head office in Chicago. Hunter has been with Crane since 1925 when he joined the company at its Springfield, Ill., branch.

Hills-McCanna Company has named **Charles Kuhn** sales manager for its Products division. Kuhn will be responsible for the sale of the company's line of pumps, valves and lubricators. He formerly was vice president in charge of sales for Fansteel Metallurgical Corporation in North Chicago.

Cardinal Chemical Company has moved **J. T. Mobley** to Hobbs, N. M., where he will be station manager. Formerly located at Odessa, Texas, he was promoted from treating engineer. With

Rockwell Opens Repair Center—

The largest gas-meter repair center in the Southeast has been opened in Atlanta by Rockwell Manufacturing Company of Pittsburgh. Designed primarily for repair and servicing of gas equipment, the new structure also will be used for repair of water meters, petroleum and industrial liquid meters and lubricated plug valves. The center will be the first major installation in that region offering meter-repair service for users of liquefied petroleum gas.

For more data on advertised products, use Readers' Service Cards, last page.

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

These "extras" pay big dividends for Pfaudler customers

Besides bringing you the benefits of over 70 years' experience in the process equipment business, Pfaudler provides a number of extra activities to help increase the industry's knowledge of corrosioneering as a whole.

CORROSION FORUMS, held several times a year, provide a three-day conference on latest developments in processing equipment. Hosted by Pfaudler, the meetings spark a lively interchange of ideas among processing men.

MAINTENANCE CLASSES teach Pfaudler customer operating personnel the proper methods of upkeep for all types of equipment, helping to reduce maintenance time and costs.

RESEARCH LABORATORY keeps its doors open to everyone with corrosion problems. This may include pretesting your product in a laboratory model of a Pfaudler Unit, such as the new conical glassed steel dryer blender. Or it may mean sending you sample buttons of glassed steel for testing with your own product at your plant. Pfaudler research people are also frequently called upon to speak or write for the benefit of the chemical industries at large.

We mention these extras – only a small percentage of all the activities at Pfaudler – to point out that, while we pay our rent with the money we earn by building equipment, we devote a great deal of effort to study and research – making every effort to provide you with the most advanced developments in design, corrosion resistance and durability.

Corrosion Forums at Rochester provide liberal exchange of operating ideas plus a quick look at the future.

How to stop contamination when processing sticky products

A good example of a clinging product is polyvinyl chloride. It sticks to most everything. And when it forms a layer on the inside of an all-metal reactor, it creates a serious cleaning problem, because material left adhering to the walls will contaminate succeeding batches.

Another drawback often encountered in metal reactors is metallic contamination, which upsets the heat stability of the resin.

You can eliminate these two hazards with Pfaudler glassed steel polymerizers. Practically nothing sticks to their smooth inner surface. Cleaning is quick and easy.

And there is no metallic contamination. Pfaudler acid-alkali-resistant glass shrugs off attack by all acids except hydrofluoric, resists alkaline solutions up to pH 12 at 212° F. This provides a broad latitude of applications which can be served by this equipment.

Your Pfaudler representative will gladly discuss your own processing needs with you. Call him or write us.

CUTAWAY VIEW of Pfaudler Glassed Steel Reactor shows two good reasons why it can easily handle sticky products: Smooth glass surface, plus a highly efficient, rigidly supported agitator which is capable of maintaining thick, heavy suspensions.

Glassed steel polymerizers improve heat transfer at General Tire

These Pfaudler Reactors at General Tire and Rubber Co., Ashtabula, Ohio, process HCl with PVC, at pressures as high as 200 psi. Once started, this reaction becomes very exothermic, and accurate temperature control becomes a vital necessity. Because glass reduces filming on the reactor walls, closely controlled heat transfer is easily accomplished with minimum impedance.

Another important problem is protecting the product from contamination by lubricants, metal, or product which has remained from earlier batches. The corrosion resistance of Pfaudler Glassed Steel prevents metallic contamination and the smooth, nonadhering surface prevents accumulation of product.

These reactors are 3500-gallon units. Since ten of them were put into service in October 1954, the records show that they have maintained a very high level of product purity and quality, with regard to particle size and temperature of processing. Write or call your Pfaudler representative for further details on the results possible with the remarkable corrosion resistance of glass plus the working strength of steel.

These glassed steel polymerizers protect the purity of PVC at General Tire.

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

the company since 1953, Mobley replaces **Gene Swindle** who was transferred to the Odessa station.

Emsco Manufacturing Company has joined with the recently-acquired Johnston Pump Company in a program to coordinate and direct the advertising of both organizations. **William J. Alexander**, advertising manager for Johnson Pump, has also been appointed advertising manager of Emsco Manufacturing, to head the new program.

Taylor Instrument Company has appointed **Alvin J. Fink** assistant regional manager for Los Angeles and the Intermountain territory. This is the second new assistant regional manager in the company's West Coast organization.

The other is **James E. Philpot** who will be responsible for industrial sales in the San Francisco area and the Northwest territory. Both men report to **George H. Linsley, Jr.**, regional manager.

Fink has been with the company 30 years, 19 of which have been on the West Coast. Philpot has been with the company since 1935 and has had wide experience in engineering, sales and administration.

Diamond Alkali Company has elected **James A. Hughes** treasurer, succeeding Arthur W. Crossley, who is leaving the company. For the past five years, Hughes has been vice president and general manager of Bryant Heater division of Affiliated Gas Equipment, Inc.

Hold Annual Sales Meeting—

The annual sales meeting of W. C. Norris Manufacturer, Inc., was held recently at the company headquarters in Tulsa. The meeting was attended by 28 men representing management and field personnel.

Front row, left to right, are: William L. Butler, executive vice president; D. P. Hagaman, assistant sales manager; Arthur Miller, Jr., sales manager; G. W. Davidson, Jr., vice-president, sales; Edward C. Bolger, president, all of Tulsa; W. J. Whitaker, sales representative, Fort Worth.

Second row: LeRoy Mitchell, Casper, Wyo.; J. A. Getty, Wichita Falls, Texas; J. G. Russell, Oklahoma City; Paul Colvard, Odessa, Texas; Hamp Brooke, Houston; A. L. Ethridge, Oklahoma City; Dan Coates, Ardmore, Okla.

Standing: J. E. Giles, Tulsa; M. L. Parker, Odessa, Texas; D. W. Stewart, Midland, Texas; Clyde C. Sights, Evansville, Ind.; R. A. Preis, Jr., Lafayette, La.; J. D. Bain, Corpus Christi, Texas; Ralph Preston, Wichita, Kans.; A. A. Hardy, Chief Engineer, Tulsa; W. C. Tolleson, Kilgore, Texas; K. M. Cook, Abilene, Texas; Kenneth Hance, Salem, Ill.; R. E. McBurnette, Shreveport, La.; C. L. Snelling, Gulf Coast district manager, Houston; C. T. Fair, Great Bend, Kans., and J. C. Schaff, Tulsa.

The Chemistry of Petrochemical Reactions

By LEWIS F. HATCH, Ph.D.
Professor of Chemistry
University of Texas

This 192-page, completely indexed volume is the only thorough and exhaustive treatise on the basic chemistry of reactions and processing of those products and intermediates popularly classified as petrochemicals.

A completely contemporary study, this book is an immediate and valuable reference for anyone engaged in either the chemical or refining industry.

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P. O. BOX 2608, HOUSTON, TEXAS, U.S.A.

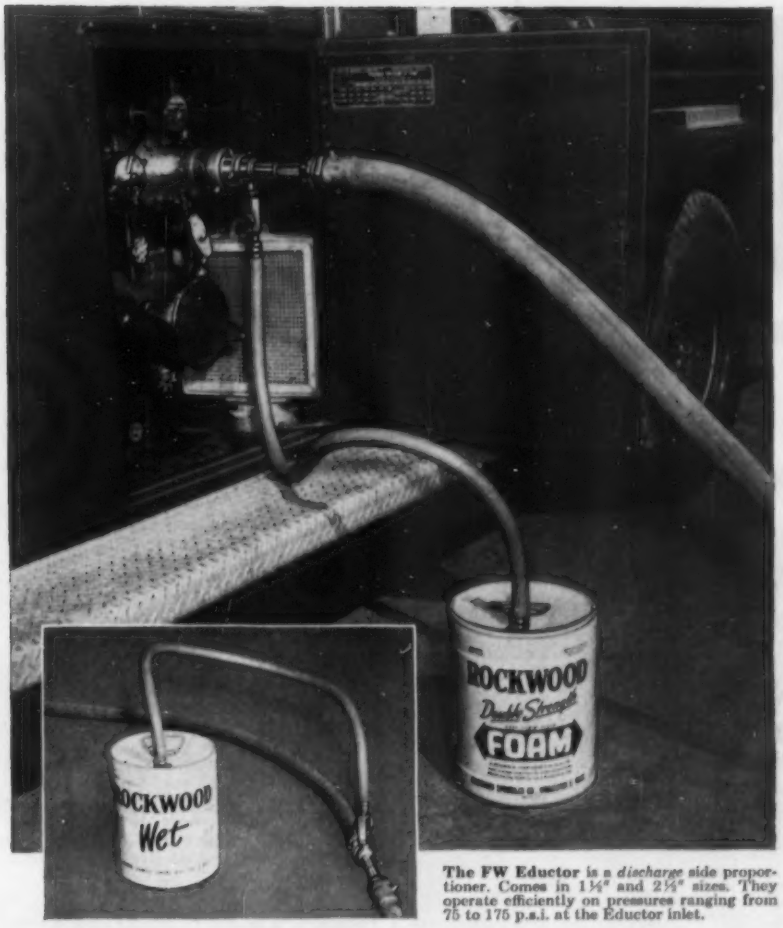
United States Steel Corporation has named **Glenn L. Martin** manager of the Orange, Texas, plant of its American Bridge Division. A veteran of 20 years with the company's Consolidated Western Steel Division, Martin was general superintendent of the Consolidated Western plant at Orange before his recent transfer to the American Bridge Division.

Leeds & Northrup Company has promoted a sales field engineer to district manager and changed the territory of another district manager. **Earle D. Moiles, Jr.**, was advanced to manager of the company's Boston office. He replaces **Paul K. Welch**, transferred to head the New York office.

Chicago Bridge & Iron Company advertising manager **Milo E. Smith** has retired after serving in that position since 1926. Smith, who joined the company's Advertising department in 1923, has been active in the Chicago Industrial Advertisers Association and the National Industrial Advertisers Association.

Cochrane Corporation has designated Dickey Engineering Company as its sales representative for Tennessee. The new agent is located in Knoxville.

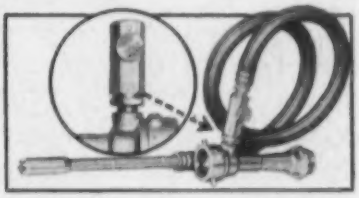
The Dow Chemical Company has made **Paul S. Foster** manager of its San Francisco office, serving central and northern California, Nevada and Utah. Foster, who started with the company in 1946, was a chemical salesman in San Francisco until 1949 when he was named assistant



The FW Eductor is a *discharge* side proportioner. Comes in 1½" and 2½" sizes. They operate efficiently on pressures ranging from 75 to 175 p.s.i. at the Eductor inlet.

FFF Nozzle comes with Foam screen and solid Foam stream shaper.

Rockwood Eductors are designed for use with both the Rockwood FFF nozzle and the SG-60 nozzle with FF extension unit. SG-60 is an all-purpose nozzle that fights fires 5 ways — high velocity WaterFOG, low velocity WaterFOG (with applicator), FogFOAM, solid stream of water or of FOAM. FF extension unit discharges Rockwood FOAM in a solid stream or as FogFOAM, and covers large areas at one time.



The Variable FW Metering-Check Valve on the Rockwood Eductor is highly versatile, and is furnished with each FW Eductor. It incorporates both the Metering Valve and Ball Check Valve in one unit, and meters material into the hose line in any proportion from 1% through 6%.

One for the road!

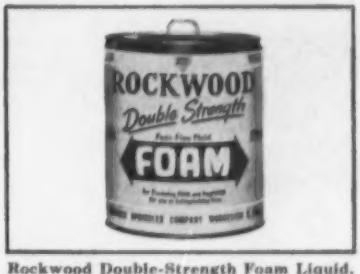
Protect against flammable liquid fire due to tank truck accidents

With more traffic on congested highways, more filling stations, more and more gasoline tank trucks in daily service, *your* city is in greater danger of a flammable fuel fire than it has ever been before. A sudden crash of a tank truck passing through your city streets tomorrow could confront you with a difficult-to-control flammable liquid fire.

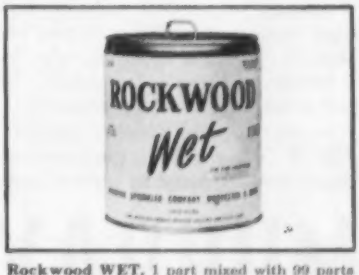
The use of Rockwood FW Eductor reduces the danger of disastrous losses due to such a fast-spreading fire. Developed for operation with Rockwood's FFF nozzle and SG-60 nozzle with FF extension unit, the FW Eductor introduces Rockwood regular FOAM, Double-Strength FOAM or WET (1% or 2%) into the hose line, quickly controlling and extinguishing flammable liquid and other fires.

Rockwood FW Eductor is the simplest form of proportioning you can buy. Ideal for municipal fire departments, oil refineries and industrial plants, it can be attached between discharge gate of a fire truck and hose line, or between hydrant and hose line, or between two lengths of hose.

Be prepared. Put this great fire fighter to work for you. Specify Rockwood FW Eductor when you order a fire truck.



Rockwood Double-Strength Foam Liquid, 3 parts mixed with 97 parts water, forms a solid FOAM blanket that quickly re-seals itself. Available in 5-gallon or 50-gallon drums.



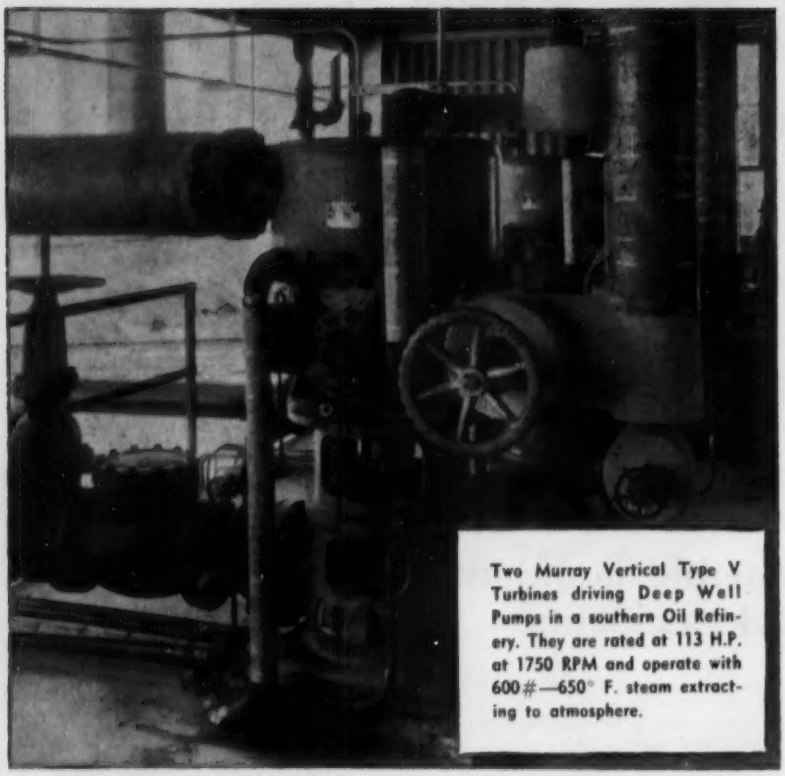
Rockwood WET, 1 part mixed with 99 parts water, increases penetration and extinguishing action of water. Excellent for deep seated fires or where water is scarce. Can be used in proportions of 1% or 2% by volume for Class A and B fires. Available in 5-gallon cans or 50-gallon drums.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

PORTABLE FIRE PROTECTION DIVISION • 1084 Harlow Street, Worcester 5, Mass.

Murray Turbines



Two Murray Vertical Type V Turbines driving Deep Well Pumps in a southern Oil Refinery. They are rated at 113 H.P. at 1750 RPM and operate with 600#—650° F. steam extracting to atmosphere.

• Murray Vertical V turbines, both geared and direct-connected, are being used more and more for driving vertical pumps of all types. The Murray Vertical V turbine is designed from top to bottom as a vertical turbine, not just a horizontal turbine, "upended." The Murray Vertical is especially constructed and arranged for vertical mounting.

Murray vertical turbines can be furnished for steam pressures up to 600#, 750° F. TT. and back pressures as high as 100# and can carry most normal thrust loads imposed by vertical pumps.

MURRAY IRON WORKS COMPANY

BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

Suppliers . . .

manager of chemical sales for Dow's Western division. In 1950 he became chemical sales supervisor for the San Francisco office.

Laclede-Christy Company, division of H. K. Porter Company, Inc., has appointed **James W. Moore** as personnel director. He recently did personnel work in the Security division of McDonnell Aircraft Company and with A. C. F. Industries, Inc.

The Girdler Company has added **Dr. Richard L. Harvin** to the staff of its Gas Processes division. He will serve as a process engineer. The company is a division of National Cylinder Gas Company.

Dr. Harvin obtained his Ph.D. in chemical engineering this year at the University of Florida where he has been engaged in research and teaching in the Chemical Engineering department since 1947.

The Airetool Manufacturing Company has selected **Paul W. Martin,** a member of its Research and Development department, to direct the company's research activities in the development of new products and improvement of its line of equipment. Martin joined the company early this year.

Wolverine Tube, Division of Calumet & Hecla, Inc., has moved its north California sales office to San Francisco. The offices formerly were located in San Mateo. The company also has appointed **R. C. Cain** as a new sales representative in that area.

Nordberg Manufacturing Company has picked Lively Equipment Company, with offices in Albuquerque and El Paso, as distributor for its line of diesel engines in New Mexico, the El Paso area and northeastern Arizona.

The Dow Chemical Company has appointed **L. A. Doan** assistant general manager of its Western division. Doan, who has been with the company since 1941, had been western sales manager for the past four years.

Sharpes Chemicals, Inc., has been dissolved as a corporation to become an operating division of Pennsylvania Salt Manufacturing Company. Sharpes was acquired by Pennsalt Chemicals through an exchange of stock in 1951. Its operation will continue without change under the direction of **Lee H. Clark,** general manager.

Climax Molybdenum Company has made **John H. Trescot, Jr.,** assistant manager of its Oil department. Before joining the company Trescot was connected with the Pipe Line department of Shell Oil Company.

Carrier Corporation has appointed **Ray A. Tritten** assistant general manager of its West Coast divisions. He will report to **William J. Bailey,** vice president heading the company's four divisions in that area.

Tritten joined Carrier at Syracuse, N. Y., in 1947 and after subsequent assignments as assistant superintendent of the

Johns-Manville announces the development of new **SIL-O-CEL 16L** *Insulating Fire Brick . . .*

Lompoc, California, where Johns-Manville mines and processes diatomaceous silica insulating materials

Combines outstanding physical and thermal properties for furnace service to 1600F

Check these properties of SIL-O-CEL 16L

Maximum service temperature	1600F, back-up or exposed
Approximate density	33-35 lb per cu ft
Transverse strength	60 psi
Cold crushing strength	350 psi
Linear shrinkage	0.7 percent at 1600F
Reversible thermal expansion	less than 0.1 percent at 1600F
Thermal conductivity (Btu in. per sq ft per F per hr at indicated mean temperatures)	0.92 at 500F 1.07 at 1000F 1.22 at 1500F

1—has less than 0.1% reversible thermal expansion at 1600F

2—provides high load-bearing strength

3—for direct exposure or back-up service

Here is a new development of Johns-Manville insulation and refractory research. Its exceptional characteristics provide important savings in furnace construction. Made of diatomaceous silica, Sil-O-Cel* 16L Insulating Brick is light in weight . . . has low thermal conductivity . . . high structural strength. And where furnace linings are subjected to severe heat shock or where high load-bearing properties are needed, Sil-O-Cel 16L offers outstanding performance.

Sil-O-Cel 16L is now available. Samples will be sent on request. Also available without obligation is Booklet IN-115A, which describes Sil-O-Cel 16L and other J-M Insulating Brick and Insulating Fire Brick for service to 3000F. Write Johns-Manville, Box 60, New York 16, N.Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

*Sil-O-Cel is a Johns-Manville registered trade mark

Replaces SIL-O-CEL Natural Brick

The development of Sil-O-Cel 16L Insulating Brick has resulted in the discontinuance of Sil-O-Cel Natural Brick. The outstanding properties of Sil-O-Cel 16L make it the ideal replacement for Sil-O-Cel Natural Brick for back-up use. In addition, the properties of Sil-O-Cel 16L Brick extend its use to exposed service applications.

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Johns-Manville *FIRST IN* INSULATION

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For more data on advertised products, use Readers' Service Cards, last page.

many more hours on stream without forced shutdown with NATIONAL AIROIL

OIL-GAS TANDEM COMBUSTION UNITS

Exclusively for vertical firing, the new National Airoil VERTICAL Tandem Block Units retain all the features of our regular horizontal Tandem Units . . . *plus:* special, pre-cast refractory shapes for easier, cost-saving vertical installation and maintenance; secondary air inlet louvres for positive control of vertical flame pattern; and, all steel duplex detaching gear which enables swift, simple vertical burner changeover.

VERTICAL and HORIZONTAL Tandem Units hold air in the combustion zone until fuel and heated air are thoroughly mixed. This means that ignition takes place in a hot zone; the result: high fuel economy through more rapid combustion with a minimum of excess air. NATIONAL AIROIL's patented Tandem Combustion Units allow secondary air to be easily and accurately controlled. By adjusting air control louvres, flame can be shaped to radiate heat uniformly without tube impingement.

The VERTICAL or HORIZONTAL Tandem Unit is always fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turndown ratio with a steady flame temperature using either fuel oil or gas. With the TANDEM UNIT'S clean flame, a cold furnace can be brought to full capacity in a short time.

"Many, many more hours on stream, without shutdown" . . . yes, YOU will realize higher profits from YOUR heaters when NATIONAL AIROIL VERTICAL or HORIZONTAL Tandem Units are specified. Our new Bulletin 498 is yours for the asking.

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CHEMICAL-PETROLEUM DIVISION

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Southwestern Division: 2512 South Boulevard, Houston 6, Texas

INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

Suppliers . . .

standards department and director of process engineering, was named chief factory engineer in the Unitary Equipment division. In 1954 he was appointed product manager for Carrier Self-Contained Weathermakers.

United States Steel Corporation has appointed **James C. Dendy** as assistant district engineer for machinery and equipment sales and service at Greggton, Texas.

Dendy joined the company's Oil Well Supply division as an engineer trainee at Hobbs, N. M., in 1953. In 1954 he was transferred to Greggton where he served in the same capacity.

Flexonics Corporation has authorized Bushnell Controls & Equipment Company to serve as its exclusive sales representative in the Los Angeles area.

Harbison-Walker Refractories Company has been granted an access permit by the Atomic Energy Commission in accordance with the government's program for industrial atomic energy development. Harbison-Walker will be given access to classified information with a view to developing a program of active participation. The company has established a nuclear research unit in Pittsburgh, headed by **C. Burton Clark**, a senior Mineralogist.

Taylor Instrument Companies has moved its former San Francisco offices and plant across the bay to San Leandro, Calif. The relocation gives the instrument concern enlarged plant facilities for that area.

The Cooper-Bessemer Corporation has assigned **S. N. Campbell** to its Houston office. He will handle engineering and sales work in that area. He formerly was stationed with the Engineering section at the company's headquarters plant in Mount Vernon, Ohio.

Borg-Warner Corporation has elected **Alonzo B. Kight** as vice president of Borg-Warner International Corporation, its export subsidiary. With the company since 1948, Kight had served as assistant to the president since 1952. A patent attorney, he was assigned to the Naval Research Laboratory during World War II.

L. O. F. Glass Fibers Company has named **Thomas L. Carver** as sales manager for its Eastern division. He previously was New York district manager for the Fiber Glass division of Libby-Owens-Ford. That division and the Corrulux division of Libby-Owens-Ford were merged with Glass Fibers, Inc., earlier this year to form the new L. O. F. Glass Fibers Company.

Johns-Manville Corporation has made **Clinton B. Burnett** general manager of its Celite division. Burnett, who will continue as vice president of Johns-Manville Products Corporation, succeeds **Arthur S. Elsenbast**, who retired. Burnett previously was director of engineering.

ACF Industries, Inc., has acquired Key Company, an East St. Louis, Ill., manufacturing concern. All property and assets of the Key Company were transferred to ACF on the basis of one share of ACF

This farm boy . . .

LIGHT WEIGHT FOR QUICK ASSEMBLY... ALCOA Aluminum Pipe weighs only one-third as much as carbon steel pipe. This means far easier handling of portable gathering lines . . . faster construction . . . easier, cheaper transportation of pipe . . . less work load in erection. (That's why farmers use ALCOA Aluminum Pipe for irrigation systems. *They* know savings when they see them.)

and this road gang

UNMATCHED FLEXIBILITY AND PORTABILITY make ALCOA Aluminum Pipe ideal for use in rough terrain. Leakproof couplings and fittings make assembly quick and easy. ALCOA Aluminum Pipe is strong, too . . . made in alloys equal to low carbon steel in mechanical strength. (That's why the construction industry uses portable aluminum pipe to bring compressed air to drills.)

show HOW ALCOA ALUMINUM PIPE CUTS COSTS

of temporary oil, gas and water lines

ALCOA Aluminum Pipe resists sulfur and hydrogen sulfide normally found in sour crude oil . . . does not cause sludging of lubricating oil or gum formation in gasoline. Because of its excellent properties at sub-zero temperatures, aluminum pipe is a natural for use in liquefied gas processes. It's nonsparking . . . may be used safely to carry inflammables.

Write today for our FREE booklet, *Alcoa Aluminum Pipe and Fittings*. Gives complete information on cutting, bending and joining plus valuable technical data.

COSTS LESS PER FOOT, TOO . . . Compared with other corrosion-resistant metal pipe, ALCOA Aluminum Pipe is far cheaper per foot.

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ALUMINUM COMPANY OF AMERICA

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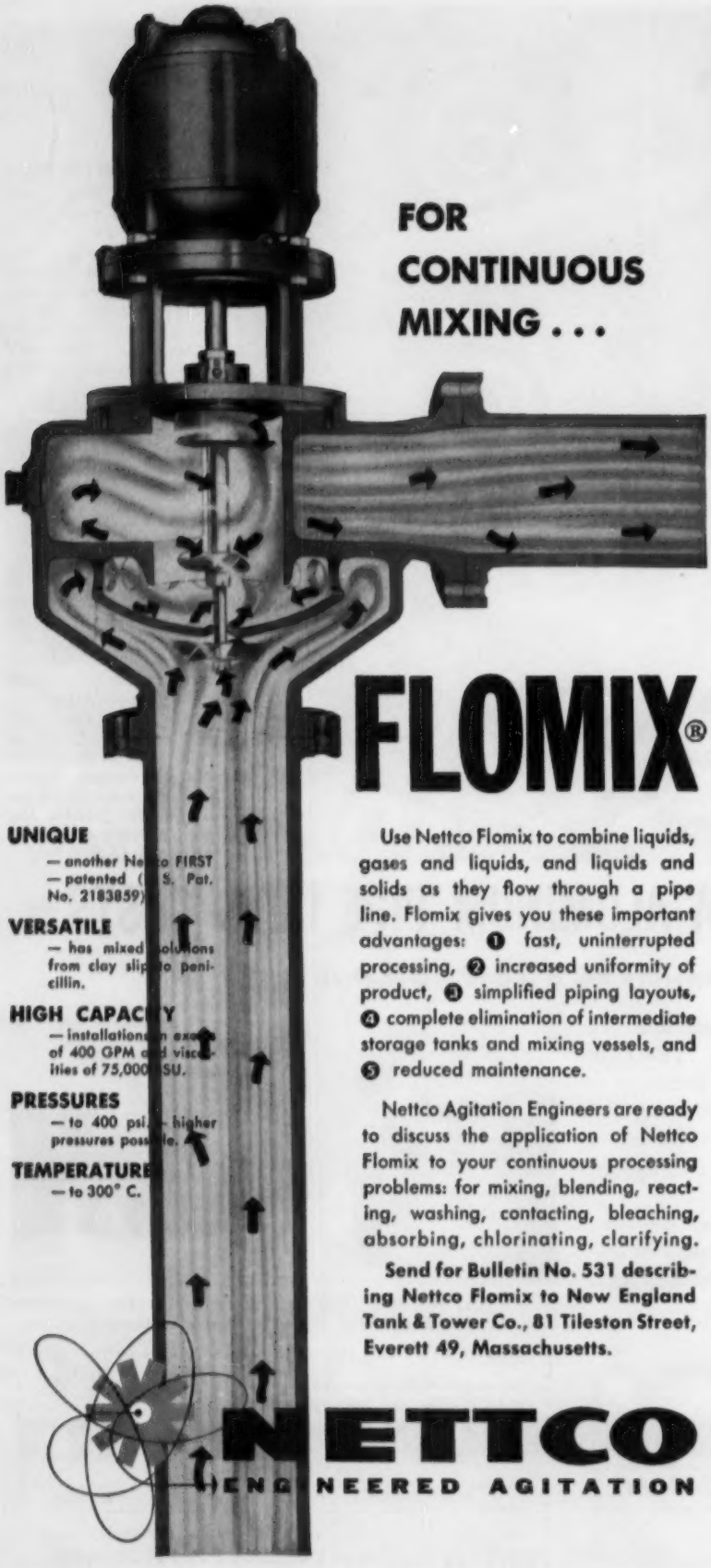
Please send me your FREE booklet, *Alcoa Aluminum Pipe and Fittings*.

Name_____
Company_____
Address_____
City_____ Zone_____ State_____



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VERSATILE
— has mixed solutions from clay slip to penicillin.

HIGH CAPACITY
— installations in excess of 400 GPM and viscosities of 75,000 SSU.

PRESSURES
— to 400 psi — higher pressures possible.

TEMPERATURE
— to 300° C.

Use Nettco Flomix to combine liquids, gases and liquids, and liquids and solids as they flow through a pipe line. Flomix gives you these important advantages: ❶ fast, uninterrupted processing, ❷ increased uniformity of product, ❸ simplified piping layouts, ❹ complete elimination of intermediate storage tanks and mixing vessels, and ❺ reduced maintenance.

Nettco Agitation Engineers are ready to discuss the application of Nettco Flomix to your continuous processing problems: for mixing, blending, reacting, washing, contacting, bleaching, absorbing, chlorinating, clarifying.

Send for Bulletin No. 531 describing Nettco Flomix to New England Tank & Tower Co., 81 Tileston Street, Everett 49, Massachusetts.

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ENGINEERED AGITATION

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common stock for four shares of Key capital stock. The recently-acquired organization will complement ACF's Houston subsidiary, W-K-M Manufacturing Company.

Carrier Corporation has organized Carrier-Houston Corporation, with headquarters in Houston, to handle all products of its Unitary Equipment division. President of the new subsidiary is **Walter H. Steitler,** who has been with the Carrier organization 21 years.

Joy Manufacturing Company has made **Lenard D. Snyder** its chief engineer for oil field products. He will headquarter at the company's Dallas plant. He has been associated with George E. Failing Supply Company, Continental Oil Company and Drilling Accessory and Manufacturing Company. He is a registered professional engineer in Oklahoma.

The Garlock Packing Company has named **Walter A. Reynolds** manager of its district office in Denver. He had been serving as sales representative in the company's lower-Michigan and northern-Indiana territory.

The Pfaudler Company has appointed **Frederick G. Josenhans, Jr.,** as district sales representative for eastern Pennsylvania. He formerly was assigned to the company's Chemical Sales department. He will headquarter in Philadelphia.

Also receiving assignments as district representatives are **John S. Volpi** and **Robert Scrimgeour.** Both had been in the Chemical Sales department since 1953. Volpi was assigned to the territory including Kansas, Oklahoma, Nebraska, Colorado and northwest Missouri. Scrimgeour was assigned to the St. Louis area.

Precision Thermometer & Instrument Company has picked a Cleveland firm, The W. M. Wilson Company, as its distributor in north and central Ohio. The distributing firm is headed by **Warren Wilson.**

Worthington Corporation has purchased from The Elliott Company a 15-acre factory site formerly owned by Crocker-Wheeler Electric Manufacturing Company in East Orange and Newark, N. J. The transaction includes a dozen existing buildings, totaling more than 330,000 square feet of working floor space.

Graver Water Conditioning Company has appointed Edward G. Moninger Company as its representative in Minnesota, North Dakota, South Dakota and northwestern Wisconsin. The new agent is headquartered in Minneapolis.

Walworth Company has concluded arrangements for the purchase of M&H Valve and Fitting Company, an Anniston, Ala., firm. Under the terms of the acquisition, stockholders of M&H will receive 5.1 shares of Walworth stock for each common share of the Alabama concern.

General Electric Company has appointed **Bertram W. Mahoney** as general manager of its Industrial Control department. He succeeds **C. A. Salmonsen** who

ONE MORE REASON TO CHOOSE PRITCHARD COOLING TOWERS:

DOUBLE PANELS INSURE TIGHTER CASING ON ALL PRITCHARD TOWERS!

The inner and outer panels, separated by a two inch nominal air space, are bolted to the tower for permanently tight horizontal joints.

Pritchard's unique casing design insures tighter panel joints and greater protection for Pritchard towers. The inner and outer panels, separate from each other, can move independently without causing gaps between panels.

All panels are factory assembled in jigs and machine nailed, even when Pritchard does not perform the field labor. Outer panels are of Clear All Heart Redwood. Inside panels are Select Heart Redwood or better. Clear All Heart trim strips, bolted to the tower, permit expansion and contraction of the casing while holding it firmly in place. Ship lap joints are placed so that drainage is to inside of tower. Each casing board is carefully planed to size for uniformity of fit.

Pritchard's unique, superior casing is one more reason to choose Pritchard cooling towers!

This nailing machine is used for precision assembly of Pritchard casing panels. Machine nailing insures superior construction.

FASCINATING READING!

Anyone interested in cooling towers or interested in learning more about cooling towers will find "Answers to 15 Questions about Pritchard Induced Draft Cooling Towers" fascinating reading! Far more than a mere catalog, this brochure has valuable advice on factors to consider in choosing towers, reliable tips on evaluating cooling tower bids. Illustrations plus cross-sectional painting take you right inside typical Pritchard tower. Write for this brochure today on your company letterhead!

INDUSTRY'S PARTNER FOR PROGRESS

COOLING TOWERS
GAS & AIR HEATING EQUIPMENT

REPRESENTATIVES IN PRINCIPAL CITIES FROM COAST TO COAST

J.F. Pritchard & Co.
OF CALIFORNIA
A DIVISION OF J. F. PRITCHARD & CO.
Dept. 497, 4625 Roanoke Parkway, Kansas City 12, Mo.

Suppliers . . .

will be assigned to special projects in other departments of the company. Mahoney has been with G. E. since 1922 and since April, 1955, has served as manager of the Industrial Control department's Roanoke Study group.

Byron Jackson Company stockholders have approved a merger with Borg-Warner Corporation. The merger plan provides that Borg-Warner will exchange four shares of its common stock for each five shares of Byron Jackson. Byron Jackson will retain its identity, management and operating policies becoming the Byron Jackson Division of Borg-Warner Corporation.

The Timken Roller Bearing Company has appointed **E. H. Hughes**, formerly manager of its Sales Order department, to a newly-created post as assistant to the sales director. He will establish a new Sales Planning department and take on special assignments.

Named as assistant manager of the Sales Order department was **J. L. Brown**, who started with the company in 1925. **Don M. Brown**, who has been with the Timken organization since 1922, was promoted to manager of the Allocations department.

The Perkin-Elmer Corporation has named **Paul Hutchinson** sales manager for its Laboratory Instruments division. Before joining Perkin-Elmer, he was associated with Baird Associates, Inc., serving as sales manager.

Edwards Valves has assigned additional territory to W. E. Bowler Company, its representative in the Philadelphia and Reading, Pa., areas. The company, headquartered in Philadelphia, now will also serve the Scranton, Pa., area.

Solway Process Division, Allied Chemical & Dye Corporation, has named **Andrew S. Clark** as construction manager in its Engineering division. With the company since 1946, Clark recently completed a year's study as a Sloan Fellow at Massachusetts Institute of Technology. In 1952, he served as project manager in charge of construction at Solway's Moundsville, W. Va. plant.

Laclede-Christy Company, division of H. K. Porter Company, Inc., has named **Delmer C. Wright** as field sales representative in the Birmingham, Ala., territory. He replaces **H. D. Roach**, who resigned.

Carrier Corporation has appointed **Philip C. Kosch** as sales manager for its Bryant division. He will be in charge of all Bryant product sales and field engineering, except regional and branch manager operations. Kosch joined the company in 1954 as sales training manager.

Aurora Pump Division, The New York Air Brake Company, has made two new additions to its eastern sales force. **Charles S. Quillen** was named sales engineer in the company's New Jersey territory, and **Schuyler B. Sterling** was appointed to Aurora's new Domestic Water System department, calling on Eastern jobbers and distributors.

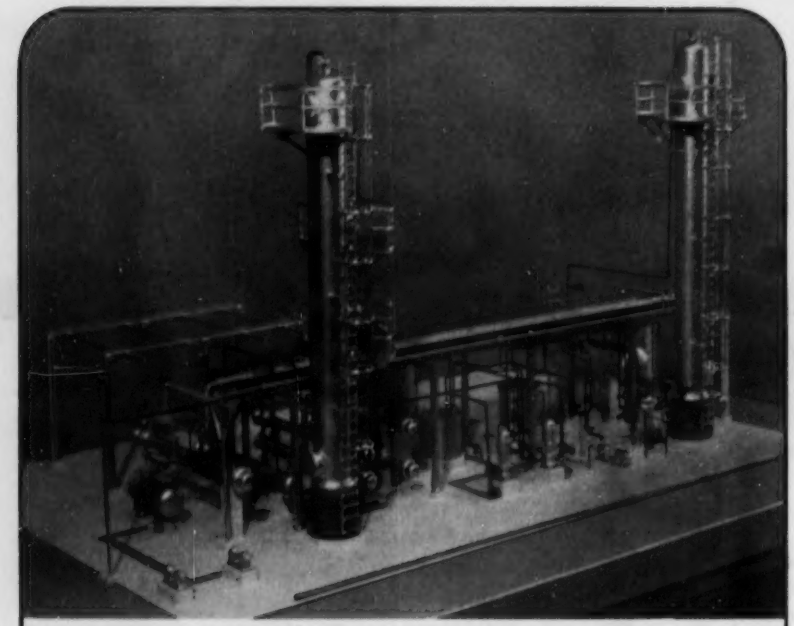
Leeds & Northrup Company has made **Elwood H. Rogge** manager of its new plant at North Wales, Pa. He formerly was the company's assistant production manager.

The Dow Chemical Company has promoted **S. G. Sevougian** to manager of its Framingham, Mass., plant. The plant manufactures chelating compounds. Sevougian formerly was production superintendent at Framingham. He has been with Dow since 1945. **Frank Kottek**, who had been production manager at the Framingham plant, was made consultant to the plant manager.

J. F. Pritchard & Company of California has selected Cone and Wallace Company, Phoenix, Ariz., distributors, as its sales representative in Arizona. The firm is headed by **Kent Cone** and **William Wallace.** Cone has been engaged in industrial sales in Arizona for 25 years. Wallace has had a variety of industrial experiences.

United States Steel Corporation has elected **Kenneth Lieber** as assistant vice president—sales for its National Tube Division. Lieber joined Consolidated Western Steel, now a division of U. S. Steel, in 1945 as a contracting engineer and since early this year has been vice president in charge of engineering for that division.

Du Pont Company has appointed **Wallace E. Gordon**, assistant director of sales for its Graselli Chemicals division, to succeed **William A. Hart** as director of the company's Advertising department. Hart, who had been with the Du Pont organiza-



Scale Model by The C. W. Nofsinger Organization.

SOHIO

CATALYTIC POLY FEED TREATING UNIT

Illustrated in the photo is a scaled down version of SOHIO's new treating unit now in operation at Lima, Ohio. Designed and engineered by the C. W. Nofsinger Company, the 2500 BPSD unit was built in model form before construction was started.

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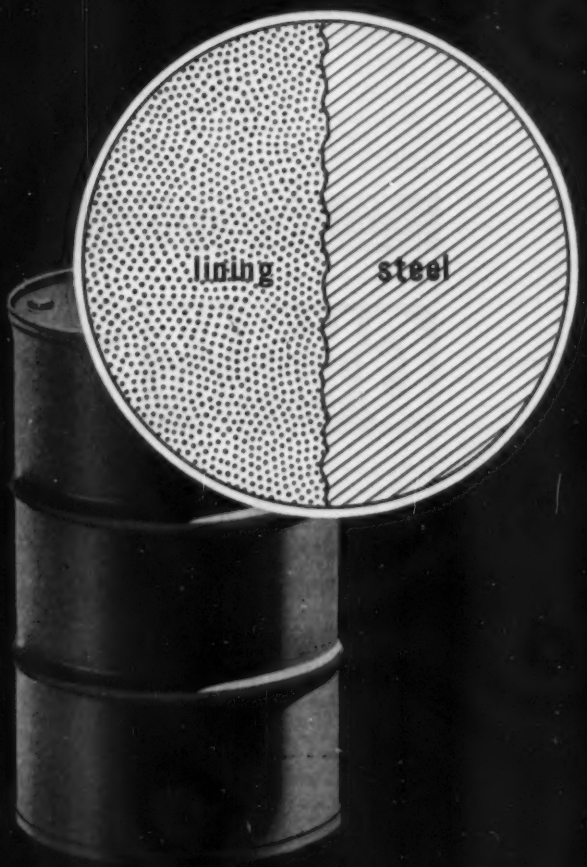
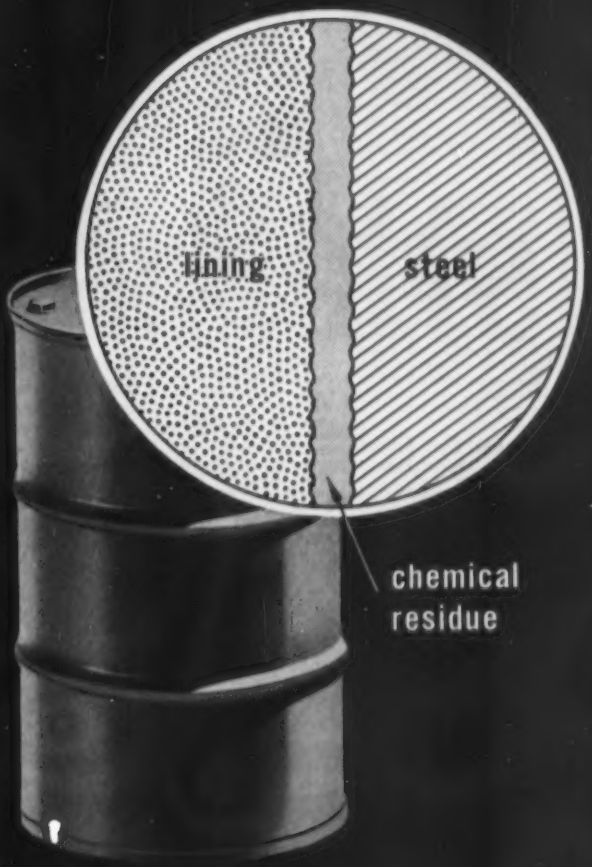


INSTEAD OF THIS . . .



...to give you longer lasting linings for steel drums

Rheem-lined steel drums *last longer*, and here are two good reasons why:

1. INTEGRATED LININGS 2. SHOT-BLASTING

Yes, Rheem linings are bonded *directly to the steel* with a bulldog grip. They're *integrated* linings. There's nothing between the steel and lining to cause flaking or peeling—*nothing that can be attacked by packaged chemicals!* And the linings last longer.

Rheem *physically* cleans and roughens its steel by shot-blasting. Bombarding the steel with high-carbon shot, Rheem can thoroughly remove scale *and* properly roughen the surface that must accept the lining. There is no chemical residue that could interfere with the lining application, and the hills and valleys of the steel offer a more positive gripping surface for the lining.

Next time you place an order for steel containers, remember this: Only *Rheem* drums have *integrated* linings. And because they last longer, they give you better protection for your product.

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Patented double - jacket design preheats lubricant and maintains constant temperature while oil is filtered. A ¼" space between outer wall and inner jacket permits preheating of lubricant . . . without use of an auxiliary heater.

All SUN filter elements fasten to the under side of the filter lid and give the operator full opportunity to check the seal of the element to the discharge connection. This feature eliminates any channeling of unfiltered oil.

The SUN filter embodies every feature engineeringly possible to assure positive filteration and maximum efficiency. Available at supply stores everywhere.

The SUN Earth filter elements are constructed in cartridge form — eliminating the need to fill elements and bypassing the danger of getting the earth filler scattered inside the filter case. The element bag is made of 8 - oz. white cotton duck. Gives long service in spite of acids, dirty lube and fuel oils.

Other Sun Filters

- SUN Regular Flow Oil Filter
- SUN Diesel Fuel Filters
- SUN Earth Filter Element
- SUN Fibre Filter Element

SUN ENGINEERING CO.

MANUFACTURERS OF SUN OIL FILTERS

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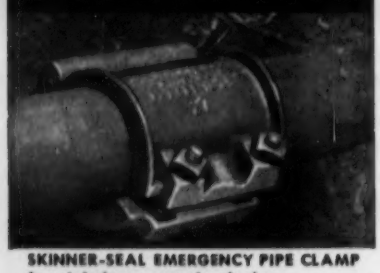
TO REPAIR PIPE LEAKS— QUICKLY, PERMANENTLY

ANY PRESSURE — ANY TEMPERATURE



SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.

SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

In stock—all supply stores

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Suppliers . . .

tion 31 years, retired. Gordon joined the company as a research chemist in 1933.

Allis-Chalmers Manufacturing Company has made **F. J. Geiger** general manager of its Norwood, Ohio, works. Manager of sales and engineering for the Electrical section at Norwood since 1944, succeeds **P. F. Bauer,** recently named manager of the Industrial Equipment division.

Kaiser Steel Corporation has appointed **Raymond J. Kopecky** accounting services manager at its plant in Pontana, Calif. Kopecky, with the company since 1949, previously was in charge of accounting. In his new post, he will be manager of accounting and office services.

Westinghouse Electric Corporation has elected **Gwilyn A. Price,** president of the company since 1946, to serve also as chairman of its board. He will continue as the chief executive officer, a responsibility he has held throughout his term as president. The board chairmanship has been vacant since 1951.

Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, has named two assistant managers for its Fine Chemicals division. They are **R. W. Eddy** and **J. J. Morris.**

Eddy has been product manager directing market development of chemical intermediates including acrolein and its derivatives and new chemicals from the company's Oxo unit. Morris has been product manager for directing market development of plasticizers and stabilizers for vinyl resins.

Leeds & Northrup Company has elected its comptroller, **Alexander H. Reynolds, Jr.,** as treasurer. Reynolds, who will continue as comptroller, takes over the duties of treasurer which **D. H. Schultz,** executive vice president, had been handling.

Rockwell Manufacturing Company has appointed **Leonard Sweet,** divisional industrial engineer of the Instrument division in Tulsa, as staff industrial engineering training supervisor with headquarters in Pittsburgh. Sweet joined Rockwell in 1948 and served as divisional industrial

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Explosion-proof models and automatic temperature compensation also available. For ranges, calibrations, and other specifics, ask for Bulletin W-4.

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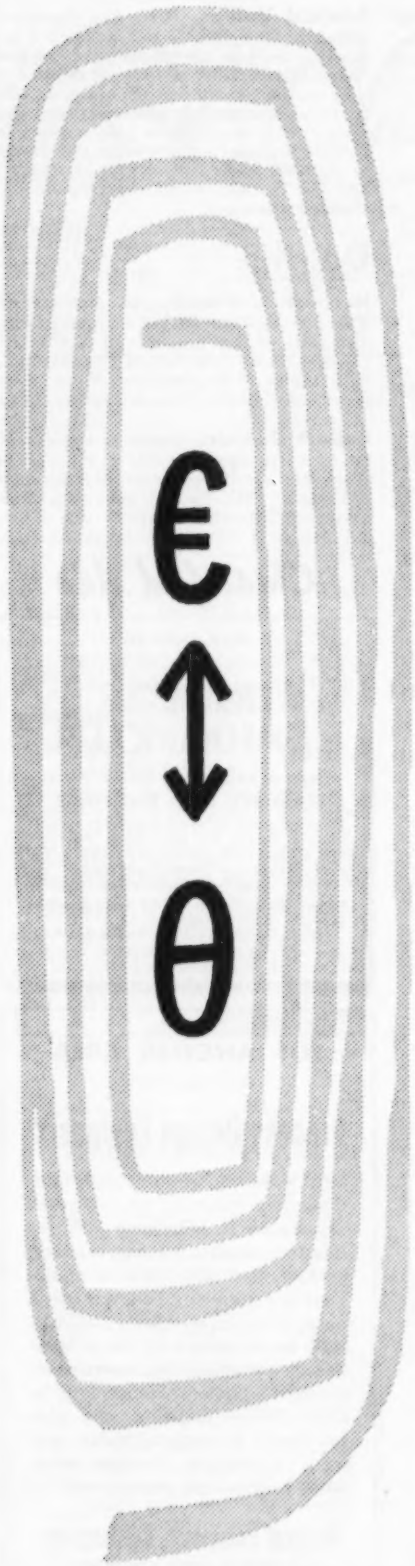

The above alchemical symbols represent limestone, coal, and salt, basic ingredients used in the lime-soda process to obtain caustic soda. These ancient symbols are portrayed in the entranceway to Wyandotte's new research center.

You can rely on Wyandotte

For a dependable supply of caustic soda

For over 65 years, Wyandotte has been a dependable producer of caustic soda.

In the petroleum industry, where caustic is used principally for removal of sulphur compounds and other objectionable impurities, Wyandotte has long been a steady supplier. Through periods of long and short supply, Wyandotte customers have benefited from a dependable and reliable source for caustic soda.

For safe, sure transportation of caustic

Wyandotte's fleet of caustic tank cars contains the MA-4 caustic-proof lining. This lining prevents iron pick-up in transit . . . assures purity on arrival!

The cars are insulated to prevent solidification of liquid caustic in any weather. Each shipment is analyzed during loading to be certain your specifications are met.

For help in caustic handling problems

Wyandotte has had much experience in the economies of caustic handling. Skilled technical service men are available to help you. They'll work with you in the construction of caustic handling and storage systems. Contact Wyandotte today.

Wyandotte Chemicals Corporation, Wyandotte, Michigan
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For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

engineer at the company's DuBois, Pa., and Freeport, Ill., plants before going to Tulsa.

Cochrane Corporation has selected **M. C. McKeown** as manager of its district sales office in Philadelphia. He was technical director of the Water Treating division and manager of the company's technical training program.

Philadelphia Gear Works has opened a new district sales office in Cleveland. Named as manager of the Cleveland office is **W. K. Kozel.** Another new district office, headed by **J. Frank Ottinger,** was opened in Baltimore.

Allis-Chalmers Manufacturing Company has established a new sales district under the management of **Walter B. Lawrence** with headquarters in Columbus, Ohio. Lawrence joined the company in 1934 and has been a sales representative in the Cincinnati district office since 1943.

The Babcock & Wilcox Company has made **Carl Claus** its director of staff, to coordinate the various functions of the staff and supervise the activities of several departments. With the company since 1931, he has been serving as executive assistant in charge of manufacturing and sales for the Refractories division. Claus will supervise the departments concerned with patents, New York personnel, student recruitment and training, employe training, purchasing, public relations, publicity.

Edward Valves, Inc., has appointed **Abraham Smaardyk,** formerly associate engineer in nuclear reactor design at Argonne National Laboratory as associate director of the company's Nuclear Engineering department. At the Argonne laboratories since 1948, Smaardyk has been working in nuclear engineering, covering the design of reactors, fuel technology, heat transfer, and reactor physics and experimental nuclear physics.

Deaths:

Herbert J. French, vice president of **The International Nickel Company, Inc.,** and assistant vice president of The International Nickel Company of Canada, Ltd., died August 17 in Rochester, Minn., after an extended illness. He was 62 years old.

Robert G. Cole, long-time employe of **Orbit Valve Company,** died July 24 in Tulsa. He was 39 years old. With the company since 1941, he had been sales manager since December, 1951.

FLORITE DESICCANT
is the best drying agent

and here's why: It absorbs water instantly from gases and liquids in either a static or flowing system, is insoluble and will not swell or disintegrate in water. FLORITE gives a low dew point depression, and agressively resists "poisoning effects" which permanently destroy adsorption qualities.

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Petroleum Refiner,
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Process Design Engineers

Must have degree in chemical engineering; minimum of five years experience in petroleum refinery design; capable of evaluating process flow diagram and equipment specifications. Follow through on mechanical design of facilities. Will be expected to make independent analyses and exercise individual judgment. Please write to Chief Design Engineer and give full details of personal history and work experience. Provide references and include photograph.

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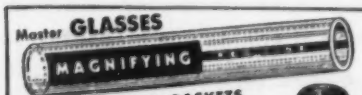

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Several graduate engineers with minimum 5 years' experience supervising maintenance engineering functions in oil refining or producing facilities, power plants, heavy industrial installations, manufacturing plants, or related operations. To establish technical supervision, procedures, maintenance operations and schedule routine and special work for major oil producing and refining operation with all supporting facilities; i.e. housing, feeding, recreation, etc.

Salaries commensurate with background and experience. Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 65

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Growing midwestern engineering contractor has an opening for a project engineer experienced in petroleum refinery or petrochemical work.

This is a permanent position and offers unusual opportunities to a well qualified man. A degree in chemical or mechanical engineering is required with a minimum of five years of experience in related work.

Interviews will be arranged for qualified applicants and all replies will be held in strict confidence.

Send resume of education, experience and salary requirements, also photograph.

Box 208-R, Petroleum Refiner, Houston, Texas.

HELP WANTED

CHEMICAL ENGINEERS

Graduates with minimum 3 years' process design experience in oil refinery or surface oil producing facilities. For New York office. Must, however, be willing to relocate in foreign operation at some future date.

Also Chemical, Mechanical and Electrical Engineers with comparable or related experience are needed for process and project work in Arabia. Assignments and salary commensurate with experience and training.

Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 23

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THE STANDARD OIL COMPANY (OHIO)

Manufacturing (Refining) Department

is looking for

CHEMICAL ENGINEERS, CHEMISTS, and MECHANICAL ENGINEERS

with one to five years experience in petroleum refining or related activities

for staff work primarily in Cleveland, Ohio.

Possible employment in Toledo, Lima, or Cincinnati, also.

Applicant should have the following educational background and industrial experience:

Chemical Engineers: B.S. or higher degree and experience in development, pilot plant operation, process design, process trouble shooting, refinery process engineering, economic studies, or related work background.

Chemists: B.S. or higher degree and experience in product and process research or development.

Mechanical Engineers: B.S. or M.S. degree and experience in process equipment construction, design, inspection, or maintenance, petroleum product testing and field evaluation, or related work background.

Age range 22-32

Salaries commensurate with experience and level in organization. Advance on merit basis.

If you can qualify and are looking for a permanent job with a growing but secure midwest company, write, giving full information on education, industrial experience, military experience, and personal data to E. G. Glass, Jr., 1737 Midland Building, Cleveland 15, Ohio.

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Organic Chemists
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with

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Positions available for qualified candidates in Organic and Inorganic Research, Development, Organic and Inorganic Production, Process and Plant Design, and Analysis.

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SOUTH AMERICA

Attractive staff positions are available with affiliates of Standard Oil Company (N.J.) for qualified experienced technical graduates.

MECHANICAL ENGINEERS—Must be thoroughly qualified and experienced design and/or maintenance of refinery or chemical plant equipment including piping, pressure vessels, heat exchangers.

CHEMICAL ENGINEERS—Assignments in process engineering would include control, design, economic studies and/or preparation of refinery operating programs.

CHEMISTS—Assignments in control or development laboratory will include product quality control and/or investigations of problems of developing new products and processing methods.

Attractive salaries, liberal annuity and savings program offered.

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PERMANENT OPPORTUNITIES

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Applicants should have at least 5 years of good design experience in any of the above fields. Applicable to heavy construction as described below—

McKEE designs and constructs Blast Furnaces, Open Hearth Furnaces, Sintering Plants and Auxiliary Facilities; Oil Refineries, Chemical and Petro-Chemical Plants. All of these afford a wide diversification of opportunities to energetic and qualified Engineers.

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Graduate engineer with minimum 10 years' experience in design or inspection of petroleum processing plants and equipment. Five years of this experience must have been in inspection work entailing general knowledge of all facilities. To develop inspection methods, supervise and conduct inspections and advise operations on codes and equipment limitations in a major oil installation located in Saudi Arabia.

Write giving full particulars regarding personal history and work experience. Please include your telephone number.

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We have an opening for a chemical engineer to head up a small process engineering group. This position is permanent and offers, we believe, outstanding opportunities for personal development and advancement. The man we are looking for will have a thorough understanding of chemical engineering principles and the ability to apply them to practical problems in process design. He will have the qualities of leadership and personality to direct the work and secure the cooperation of the other members of the group. He will have had a minimum of five years experience in process design of petroleum refining or petrochemical plants.

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To supervise Pilot Plant program including design & operation. Require alert young Engineer with good scholastic standing & at least a few years experience in pilot plant operation, preferably in charge of a few Engineers for at least 1 year. Aptitude for Pilot Plant Design & operations, eagerness to attain development objectives, and leadership are also essential requirements.

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To participate in interesting program comprising chemical engineering calculations, design & pilot plant operation. This varied activity should appeal strongly to recent graduates with 0 to 3 years experience.

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Salary commensurate with qualifications and experience. Liberal moving allowances.

Write furnishing complete particulars regarding educational qualifications, work and salary history, salary desired, business and character references.

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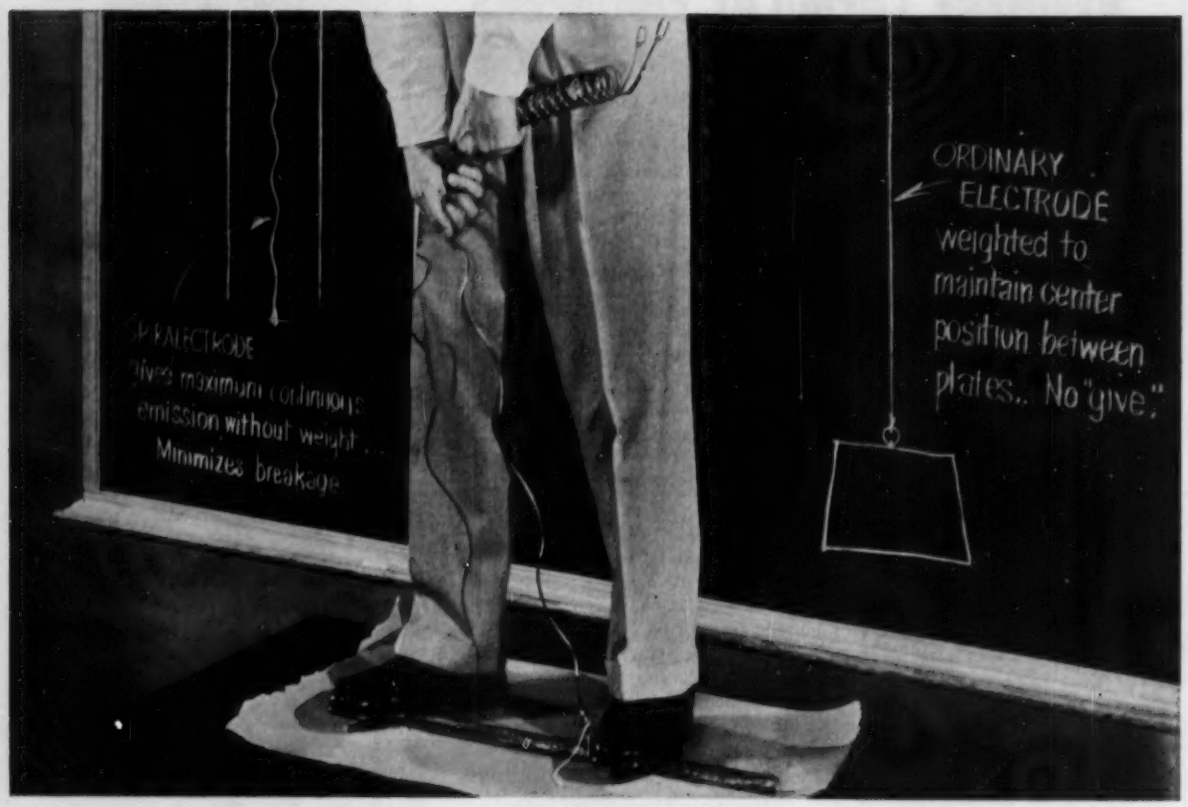
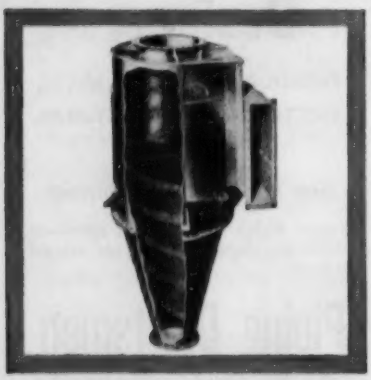
For more data on advertised products, use Readers' Service Cards, last page.

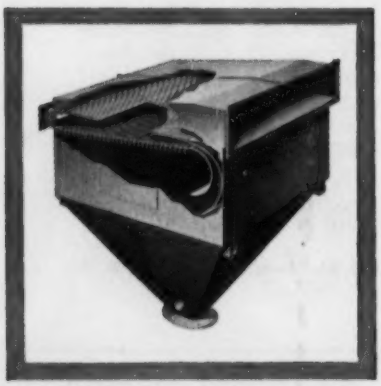
Electrode Breakage is no problem in Buell "SF" Electric Precipitators





Buell Cyclones offer two "extra-efficiency" advantages: (1) exclusive shave-off which harnesses double-eddy and puts it to work, and (2), large diameter design which eliminates clogging.

Besides eliminating efficiency drops and "shutdowns" due to electrode breakage, Buell's unique Spiralectrode permits higher and more constant emission, extra efficiency. Also, Continuous Cycle Rapping—another Buell exclusive—keeps electrodes constantly clean for maximum performance!



Buell's Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for natural or forced draft installations. Ideal for boilers from 100 to 2000 BHP.

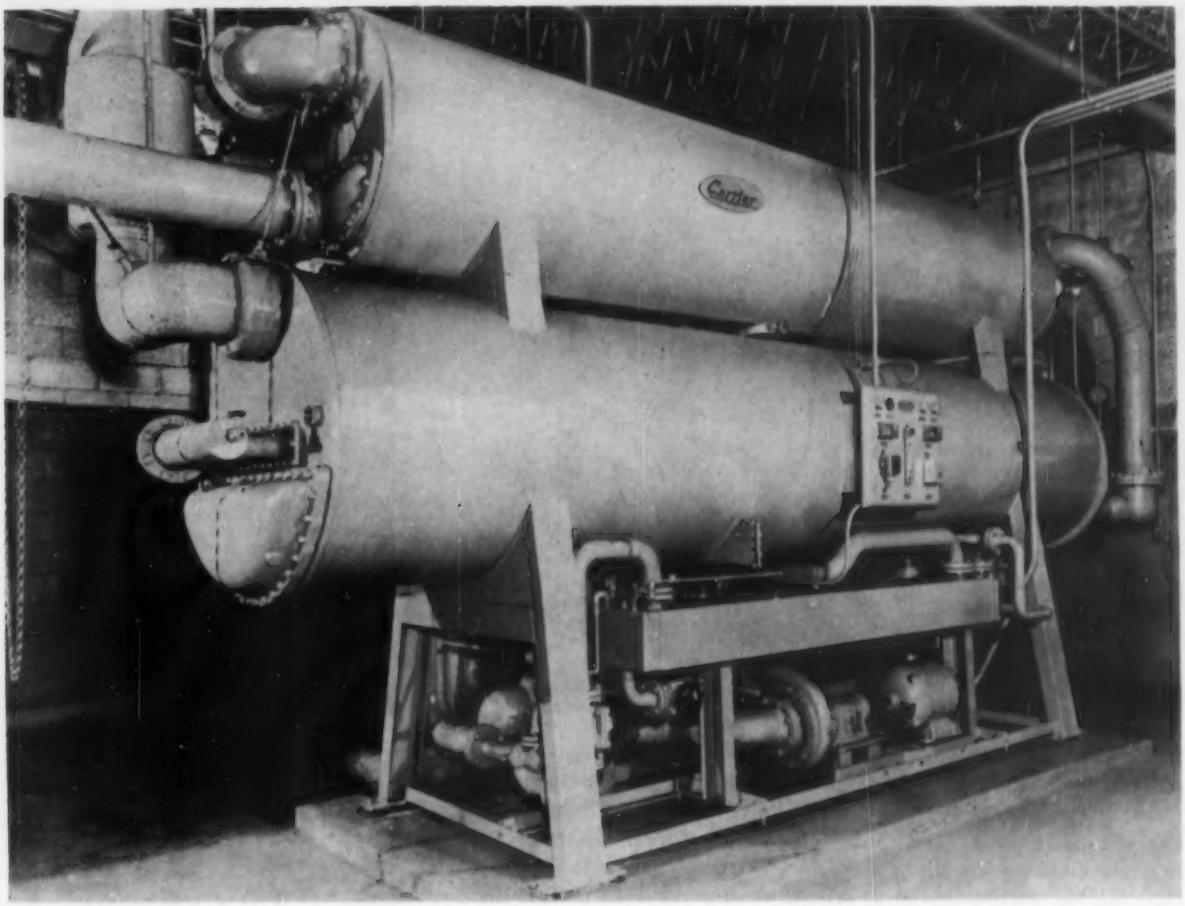
For more specific data about Buell's *extra efficiency*, write Dept. 21-I
Buell Engineering Company,
70 Pine Street, New York 5, N. Y.

buell

MECHANICAL ELECTRICAL

Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

What's New In Equipment . . .



Large-Capacity Refrigeration Produced by Absorption Unit

Absorption Refrigeration machines which have no major moving parts and produce chilled water from steam are now available for large-capacity process cooling installations in a wide range of sizes from 100 to 700 tons. Handled by Carrier Corporation, the new type absorption machines, which will adjust automatically from full load down to almost zero load with little loss in efficiency, are designed to produce low-cost cooling from economical sources of heat such as natural gas or steam.

The units are suitable especially when a by-product source of steam is already available such as excess process steam or exhaust steam from back pressure turbines. The unit will operate on steam pressures as low as 12 psig. The light weight and lack of moving parts make this absorption equipment suitable for installation in almost any location either at grade or in structures so that it may be closely associated with its process use.

Equipment is also quiet and when an operation is not objectionable for installation adjacent to office spaces. The high efficiency performance throughout the entire range of capacity from almost zero load to 100 percent load is of special value in certain industrial applications requiring smooth and rapid load fluctuations of cooling equipment.

Functional nature of the equipment is such that overloading will in no way damage or injure the unit. The machine will produce capacity much in excess of normal load but the temperature of the coolant will rise proportionately. For further information . . .

Circle E1 on Postcard

Valve Positioning Relay Kit is announced by the Bailey Meter Company for field application to any air-operated control valve. This kit provides a relay to assist in positioning problems such as stuffing box friction load, response misbehavior, unbalanced inner valves, hysteresis, and undesirable regulating characteristics. Standard SAMA signal ranges of 3-15 psig or 3-27 psig actuate a force-balance mechanism. As little as 0.065 psig input signal change will apply full output (50 psig max) to the motor valve.

The relay is direct or reverse acting and suitable for top or bottom connected valves. Six preshaped cams are supplied for square

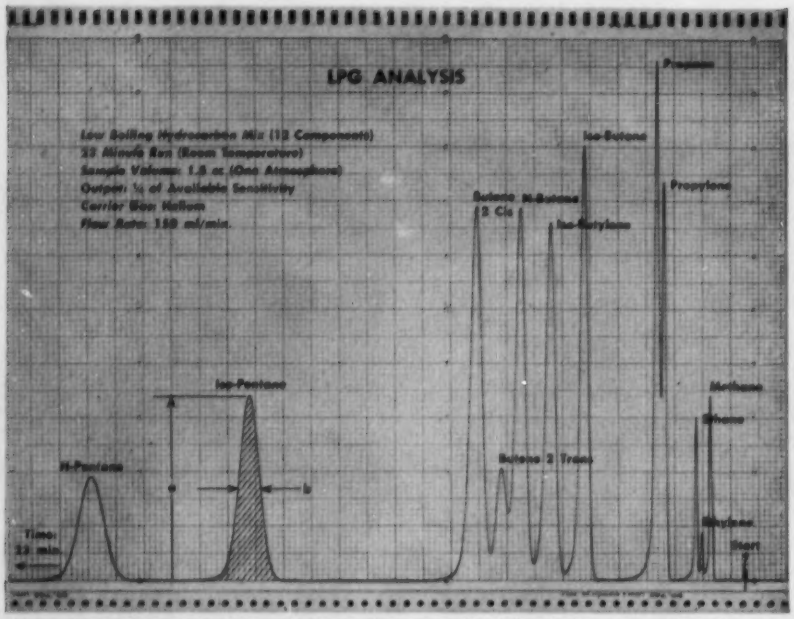


Photo of actual run made on new P-E Vapor Fractometer. To find mole % concentration of a component, analyst simply integrates area under peak by multiplying peak height (a) times half-band width (b).

This quantitative analysis took only 23 minutes on the new P-E Vapor Fractometer that costs only $1,375

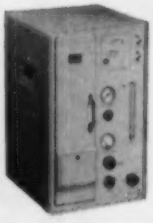
HOW LONG WOULD IT TAKE YOU?

Employing the principles of gas chromatography, P-E's new vapor fractometer is a revolutionary advance in the field of gas and volatile-liquid quantitative analysis. It is fast, precise, uncomplicated to operate, extremely simple in calculation, and above all, many times less expensive than distillation columns, mass spectrometer, or any other instrument, for the purpose.

For qualitative analysis, the instrument gives extremely clean separations—even of components and isomers which cannot be separated by ordinary methods. For trace analysis, high sensitivity permits use of extremely small samples.

Take, for example, the analysis of a synthetic LPG mix shown above. Here 12 components, representing the hydrocarbons most frequently encountered, were clearly separated—a job extremely difficult to accomplish by ordinary vacuum distillation methods. The perfect shape of the recorder bands makes quantitative analysis simple and accurate. Area under each peak is the measure of the mole % concentration of the component. These area relationships are all that is needed for calculation, without preliminary calibration for each individual component.

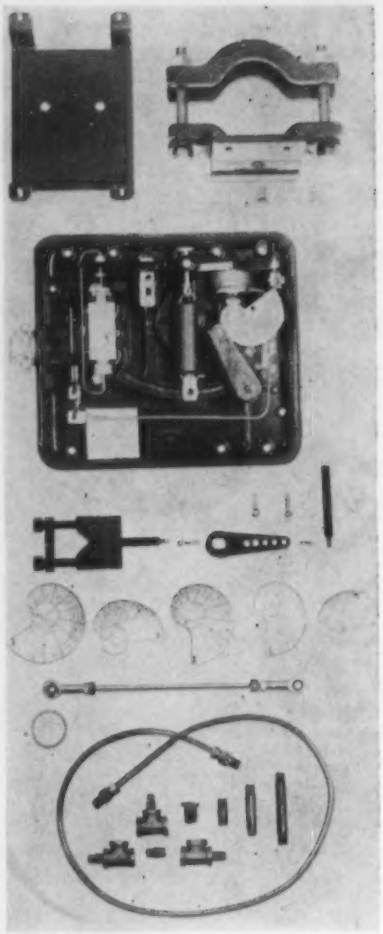
There is no faster, no simpler, no more inexpensive method in existence today.



This is the Model 154 Vapor Fractometer—price, $1375.00 without recorder. Send for descriptive bulletin.

Perkin-Elmer CORPORATION
Norwalk, Connecticut

New Equipment . . .



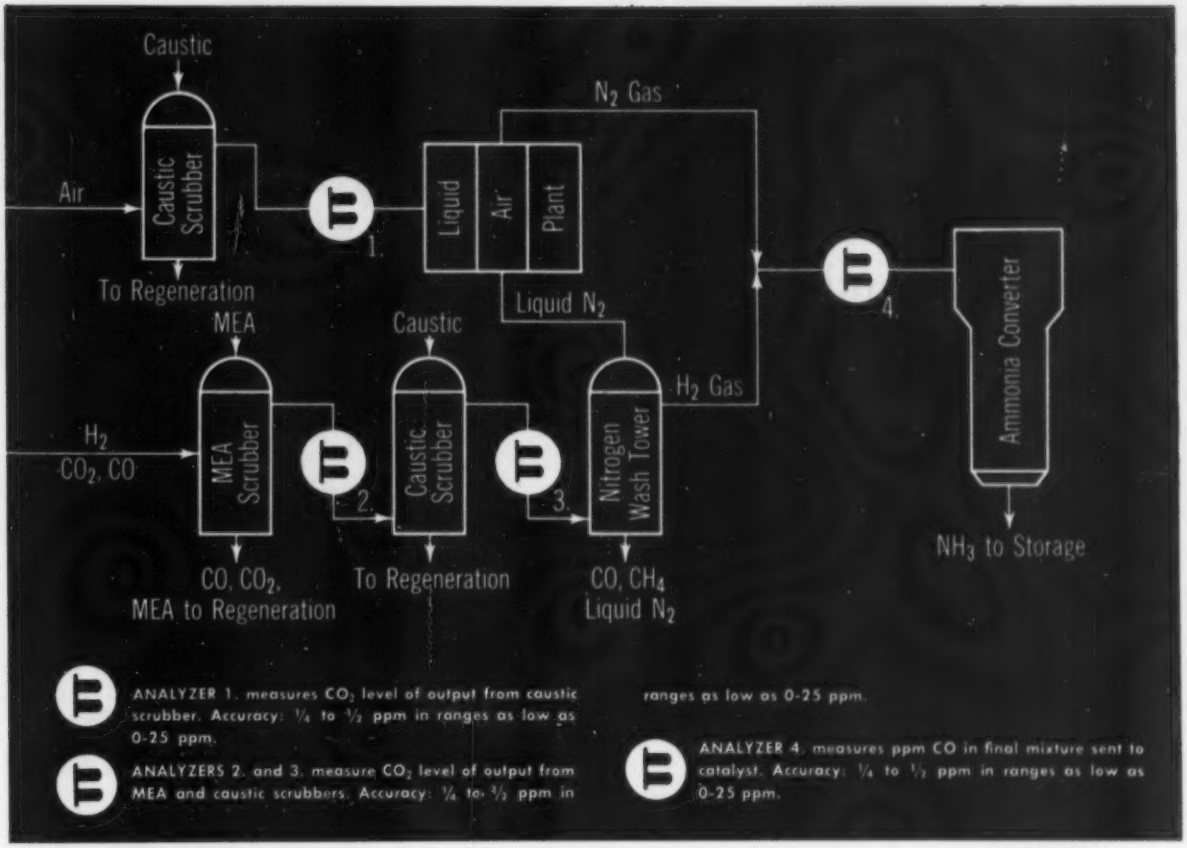
root, linear, square, and half-travel regulating characteristics. Further field shaping is simplified by polar co-ordinate imprints on cams. A spring clip locks supply and by-pass air valves in place. Dust and moisture tight cover gasket protects the simple and sturdy relay mechanism. To get details on this positioning relay kit just . . .

Circle E2 on Postcard

This item supplements Bailey Meter Co. data on pages 178-179 of The Refinery Catalog, 22nd Edition.

Six-Ton Crane for Light Materials Handling and Industrial Applications has been developed by the Schield Bantam Company. This crane is self-propelled and full control of both carriage motion and crane operation is through a single operating position, thus, one operator only is required.

The unit has an outside turning radius of 19½ feet which gives it extreme maneuverability for getting into tight working quarters such as are frequently encountered within battery limits of process units. The steering mechanism and brakes for the carriage of the unit are hydraulically controlled with the crane control through mechanical devises. The standard arrange-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Air
Caustic Scrubber
To Regeneration
1.
Liquid
Air
Plant
N_2 Gas
Liquid N_2
4.
Ammonia Converter
NH_3 to Storage
MEA
Caustic
H_2
CO_2, CO
MEA Scrubber
2.
Caustic Scrubber
3.
Nitrogen Wash Tower
H_2 Gas
CO, CO_2, MEA to Regeneration
To Regeneration
CO, CH_4 Liquid N_2
ANALYZER 1. measures CO_2 level of output from caustic scrubber. Accuracy: ¼ to ½ ppm in ranges as low as 0-25 ppm.
ANALYZERS 2. and 3. measure CO_2 level of output from MEA and caustic scrubbers. Accuracy: ¼ to ½ ppm in ranges as low as 0-25 ppm.
ANALYZER 4. measures ppm CO in final mixture sent to catalyst. Accuracy: ¼ to ½ ppm in ranges as low as 0-25 ppm.

in a 250 ton per day ammonia plant . . .

CONTINUOUS ANALYZERS INCREASE OUTPUT 10%

. . . save $16,000 a year

Perkin-Elmer *continuous* infrared analyzers can increase the efficiency of *your* process – by doing away with "analytical lag," moving the laboratory right out to the process line. Take this example of an ammonia plant.

A P-E TRI-NON* Analyzer (Number 1. in flow diagram) continuously measures CO_2 level–determines optimum balance between caustic use and CO_2 removal efficiency. If NH_3 throughput is 250 tons a day, raising caustic utilization from 70 to 80% or more means a saving of $4,500 to $6,000 a year.

Analyzers 2. and 3. measure the CO_2 level of output from MEA and caustic scrubbers. At this level, the equipment is paid off in less than a year.

Analyzer 4. measures ppm of CO in final mixture sent to the catalyst. With proper control of CO level, $8,000 to $10,000 can be saved by extending catalyst life. The analyzer pays for itself in 6 months!

When you specify continuous analyzers for your process streams, only P-E has a complete line of instruments to choose from. Or let us develop a complete analytical control system for you. Nowhere else can you get the combination of chemical engineering and instrument know-how that you'll find at P-E. *T. M.

Perkin-Elmer

CORPORATION

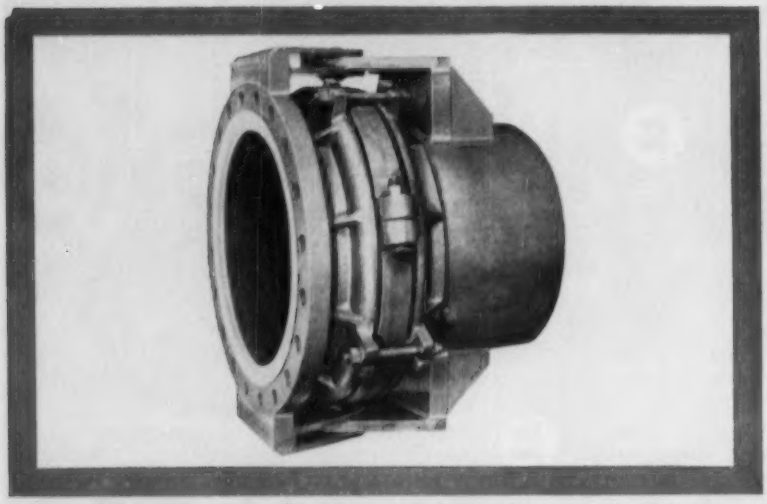
Norwalk, Connecticut

P-E TRI-NON Analyzers are available in a wide range of models and prices to meet all types of continuous analytical problems. They are rugged and dependable, expressly designed for use in the varied environments of a processing plant or refinery. For quick and easy maintenance, instrument components can be tested right on stream — without disconnecting.

For more data on advertised products, use Readers' Service Cards, last page.

FLEXON PIPING *Operating Briefs*

How to Handle Angular Motion in Steam and Process Piping



FLEXONICS
A Single Source for Every Expansion Joint Requirement

Flexonics Corporation manufactures a complete line of expansion joints in free-flexing, controlled-flexing and special types. Sizes range from 3" up.

Ask for your copy of the Flexon Expansion Joint Design Guide. It provides application and installation data for a wide range of services.

Piping motion where expansion joint flanges do not remain parallel under operating conditions can often be handled best by a Flexon hinged-type expansion joint.

The Flexon hinged-type joint is self-restrained to prevent any thrust from being transmitted to adjacent piping. The economy of the hinged unit comes from the elimination of much of the expensive anchoring and guiding necessary in a conventional installation.

Flexon hinged-type expansion joints are available in both free-flexing and controlled-flexing types in all standard sizes with two or more corrugations. Flanges, welding ends or a combination of the two are available.

Hinged-type expansion joints are just one of the types offered by Flexonics. Whatever your needs, bring your expansion control problems to Flexonics. For specific recommendations send an outline of your requirements.

Flexonics *Corporation* — EXPANSION JOINT DIVISION

1336 S. THIRD AVENUE • MAYWOOD, ILLINOIS

FORMERLY CHICAGO METAL HOSE CORPORATION

Flexon identifies products of Flexonics Corporation that have served industry for over 53 years.

Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

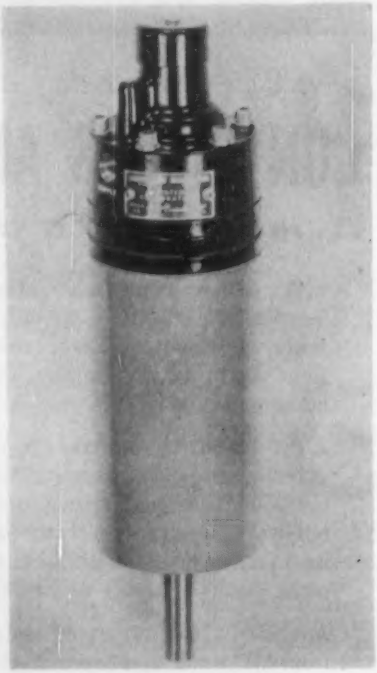
New Equipment . . .

ment on this crane carries 25′ boom with counterweights. The rig can also be outfitted with a back hoe attachment. The nominal excavation rating is ⅜ cubic yard.

For maximum operator visibility the new rig has an all-vision cab giving the

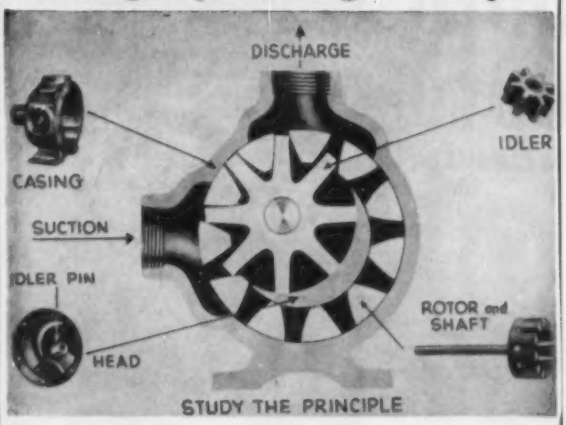
operator 360 degree visibility for traveling, backing and working. The new cab offers easy access to all working parts for repair, servicing, and adjustment. The wheel base is 112 inches with an over-all length of 173¼ inches. The width over-all is 96 inches and an over-all rig height of 125 inches.

Circle E3 on Postcard



Power Operator in a small compact version of the Conoflow Series 50 line of pneumatically positioned operators has been developed by Conoflow Corporation. The B-50 Cylinder Conomotor is capable of producing stroke lengths of 2 inches and thrusts of 300 pounds in either direction. It is suitable for use with supply pressures to 100 psi with a conventional 3-15 pound

Viking Operating Principle



Above are illustrated the major parts of the Viking Pump—casing, head, rotor and idler, separately and assembled. Imagine the rotor and idler in motion operating in a counterclockwise direction. Follow the course of the liquid from point of suction to point of discharge. Reverse direction will operate equally well. We invite your inquiries.

Distributors

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Here's vital information for ready reference on the new Tri-Forged steel grating and stair treads, plus latest information on Tri-Lok interlocked products. This fact-filled catalog gives you installation specifications, types of grating and stair treads available, and safe load tables. Be sure to write for your copy today.

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the role of American companies in the global revolution in oil

How Americans are in the forefront of a truly global revolution in oil, what these changes are, and what they mean to free nations is told in this book. The author, an oil expert, shows how U. S. overseas oil development helps hold back Communism, enables foreign nations to help themselves, and insures an adequate supply of oil for the Free World. The author analyzes overseas oil operations in Mexico, Venezuela, the Near East, Canada, and many other lands.

What positive steps must be taken to offset the military and economic threat of dwindling oil resources is shown by the author. He reports on what U. S. companies are already doing to carry on oil development overseas despite the pressures of Communist intrigue, power politics, and fanatic nationalism. The book gives you a behind-the-scenes look at the expropriation of Mexican oil lands, Venezuela's initiation of 50-50 profit sharing, the settlement of the Iranian oil dispute, and many other important happenings in the international oil picture.

Just Published!

FOREIGN OIL AND THE FREE WORLD

By Leonard M. Fanning
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THE N. Y. TIMES SAYS:
"Mr. Fanning makes an impressive case for the thesis that the U.S. oil companies operating abroad have done and are doing a satisfactory job and that they should be encouraged by the U. S. government"

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Attach your check or Money Order and shipment will be made promptly via prepaid Parcel Post.

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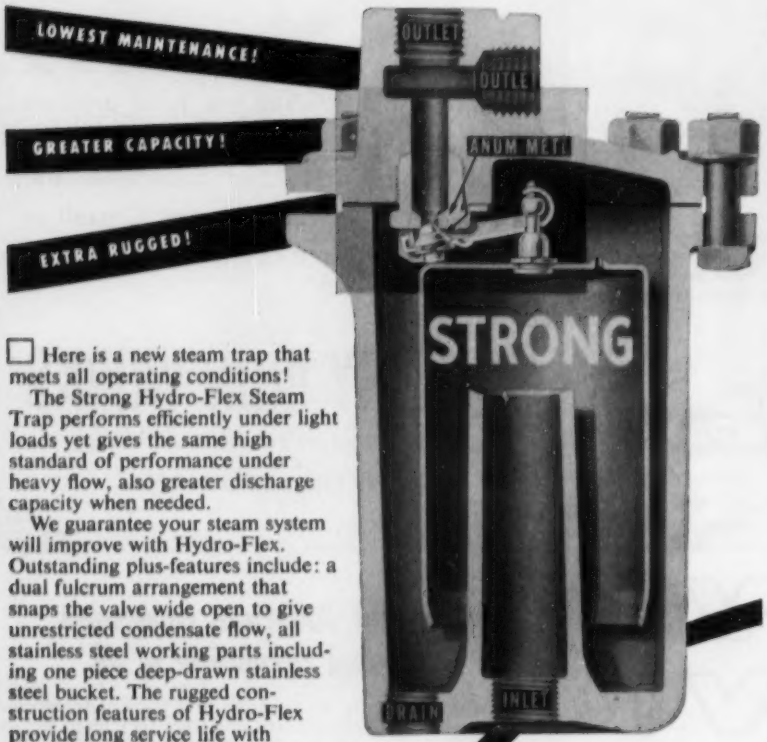
NEW WAY TO

REDUCE STEAM COSTS

AND INCREASE PRODUCTION



☐ Here is a new steam trap that meets all operating conditions!

The Strong Hydro-Flex Steam Trap performs efficiently under light loads yet gives the same high standard of performance under heavy flow, also greater discharge capacity when needed.

We guarantee your steam system will improve with Hydro-Flex. Outstanding plus-features include: a dual fulcrum arrangement that snaps the valve wide open to give unrestricted condensate flow, all stainless steel working parts including one piece deep-drawn stainless steel bucket. The rugged construction features of Hydro-Flex provide long service life with minimum maintenance.

Your local Strong distributor will give you complete information or write us for Bulletin No. SS-40.

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STRONG HYDRO-FLEX STEAM TRAPS

high efficiency under all condensate loads

HORIZONTAL TYPE SERIES
Hydro-Flex traps with horizontal inlet have the same features as bottom inlet types.

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3 types available for wide range application . . . to meet pressure and capacity requirements.

PRESSURE REGULATING VALVES

are custom sized for job demands. Bolted body permits non-threaded seats and wide selection of seat sizes.

BLOW-DOWN VALVES

STRONG STRAINERS
Offer maximum protection from dirt, scale or sediment. Available in semi steel, cast steel and bronze.

New Equipment . . .

psi single range. These features, plus its all-around compactness, make it ideal for services where heavy loads require high accuracy throttling in a minimum of space. For detailed information on this power operator . . .

Circle E4 on Postcard

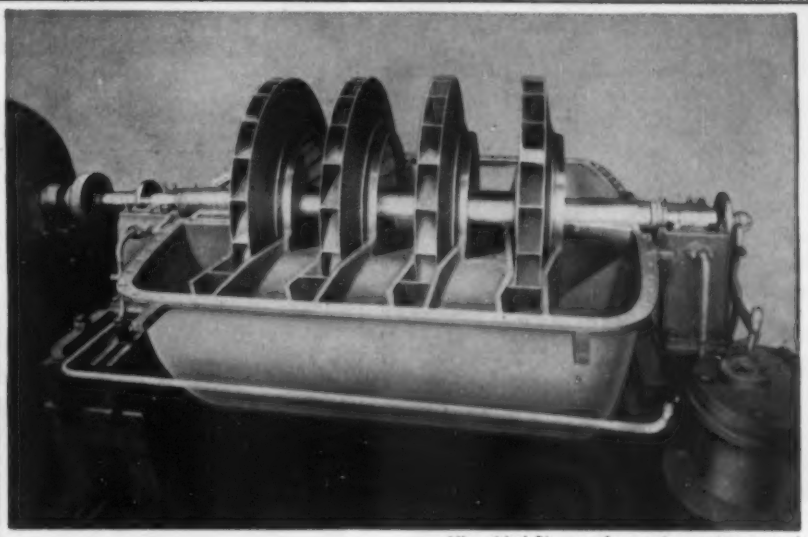
Flexible Liner Pump has been developed by Vanton Pump and Equipment Corporation. This pump was created specifically to function under conditions which ordinary pumps could not withstand. The chief feature of the new pump is a precision molded flexible liner which is the key to the non-corrosive, non-contaminating characteristics of the pump. The only parts of the pump which come in contact with the fluid being pumped are the outer surface of the Flex-i-liner and the inner surface of the pump body block so that the pump never touches any metal which could cause contamination and corrosion in certain services.

The pump has no stuffing boxes, shaft seals, check valves, glands, or gaskets. The design of the pump lends itself to easy adaptation to unusual services. The Flex-i-liner can be molded from a variety of materials, each of which has certain characteristics of resistance to various fluids. Liners molded from Hycar American rubber, a versatile raw material supplied by B. F. Goodrich Chemical Company, are used in many Vanton Pump applications where resistance to the corrosion of oil, chemicals and abrasive slurries is a problem. For more information on this unique pump, just . . .

Circle E5 on Postcard

Automatic CO_2 Shielded Welding Equipment has been developed by General Electric Company. The company has developed a completely new automatic, consumable-electrode welding unit that is especially adapted for use with low-cost carbon dioxide shielding gas. The equipment is the outgrowth of industry-wide efforts to find a practical method of using gas-shielded welding for mild steel applications at costs which may be the same or below the cost of submerged-arc processes.

Consumable-electrode welding of mild steel with carbon dioxide is out of the experimental stage and is practical for pro-



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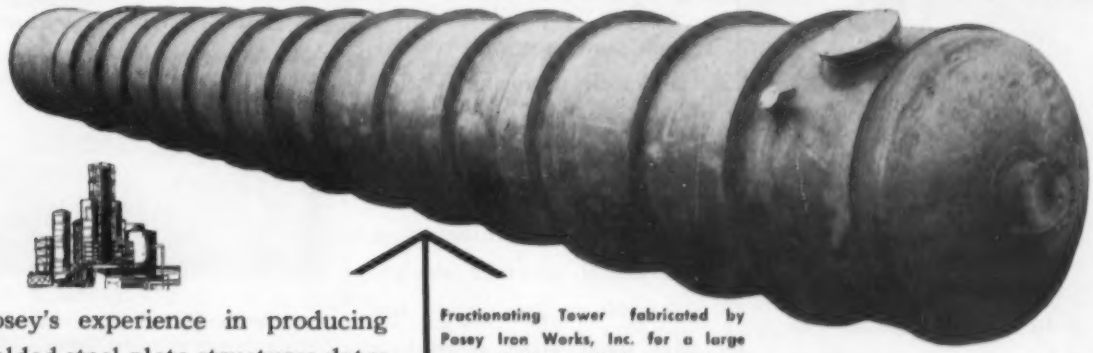
POSEY FRACTIONATING TOWERS



Fractionating Tower fabricated by Posey Iron Works, Inc. for a large chemical plant in Michigan. 8′ diameter . . . 70′ high . . . ⅜″ skirt . . . ½″ shell and head . . . ⅜″ trays

Posey's experience in producing welded steel plate structures dates back to 1910 . . . so Posey has the experience as well as the facilities to design, fabricate and erect almost any type of structure required by the Petroleum Industry. You can trust Posey for refinery structures built to your most rigid specifications. Please write for information or estimates without obligation.

Steel plates fabricated by Posey meet all ASME, API-ASME and API codes

ELEVATED TANKS • HORIZONTAL TANKS • STACKS
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CARBON STEEL AND ALLOY STEEL PLATE FABRICATION
DREDGE PIPE AND ACCESSORIES

POSEY IRON WORKS, INC.

Steel Plate Division Lancaster, Penna.
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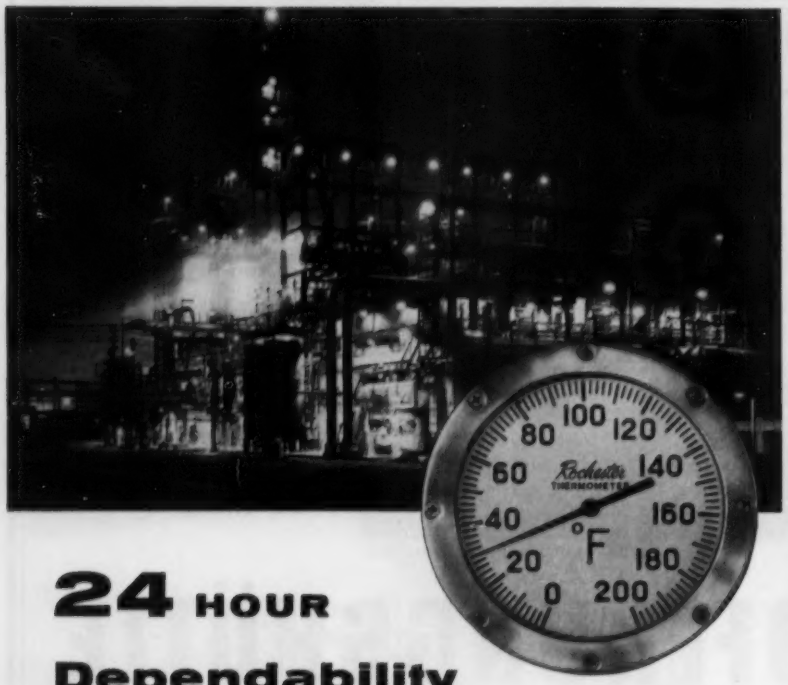
For more data on advertised products, use Readers' Service Cards, last page.



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Rochester builds dependable and accurate round-the-clock performance into every thermometer. This is made possible by over 40 years experience in precision instrument manufacturing, advanced product design, top volume production and the most rigid inspection standards. That's why . . .

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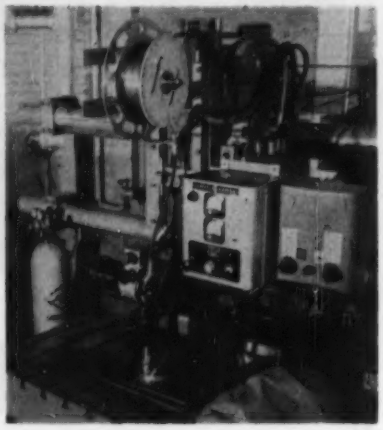
ROCHESTER DEPENDABLE ACCURATE GAUGES
DIAL THERMOMETERS GAUGES AMMETERS

New Equipment . . .

duction applications. In this process the consumable-electrode is fed to the arc and no flux is used. Thus, the operator can see the arc clearly and inexpensive fixtures can be used. Also, the clean-up problem associated with flux has been eliminated.

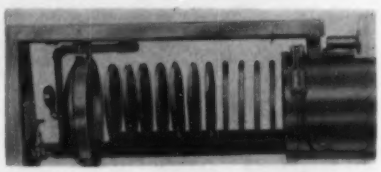
The new G-E Fillerarc equipment includes wire-feeder, torch, control panel,



reel mount and motor-generator unit. It employs extremely high wire speeds (up to 1,000 inches a minute) and very short arc lengths to produce a deeply penetrating arc with a minimum of spatter. The technique also causes violet agitation in the weld puddle, allowing more porosity producing gas to escape. As a result, the welds are of higher quality. For a copy of GEC 1334, the complete specification on this equipment, just . . .

Circle E6 on Postcard

This item supplements General Electric Company data on pages 442-443 of The Refinery Catalog, 22nd Edition.



Horizontal Filters with new features have been announced by Industrial Filter and Pump Manufacturing Company. These features include a quick opening hydraulically operated and sealed door, and filter leaves which lift out and snap back into place without bolts. An optional vibrating attachment shakes off the filter cake, eliminating the need for scraping or shaking by hand. For full details on bulletin NH-155 . . .

Circle E7 on Postcard

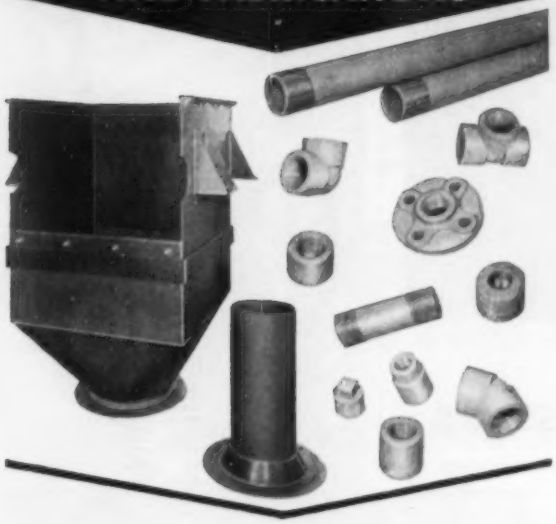
Electro-Hydraulic Control Valve Operator of a new type has been announced by Manning, Maxwell & Moore, Inc., Industrial Controls Division. This unit is said to eliminate all need for air supply usually used to operate control valves for process variables such as pressure, temperature, flow, etc.

The new control valve operator is specifi-

STOP Corrosion with...

Van-Cor

PLASTIC PIPE, FITTINGS AND FABRICATIONS



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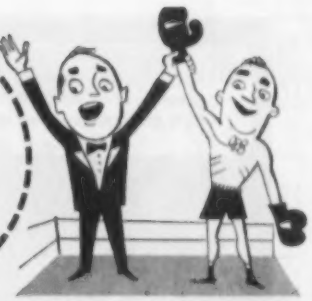
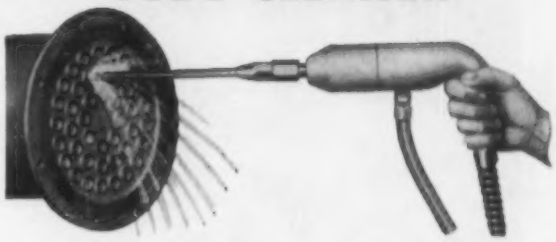


WILSON PGX

TUBE CLEANER



The Wilson PGX Tube Cleaner weighs only 6 1/2 pounds, but it knocks out scale ten times faster than ordinary mechanical cleaners. It cleans at rates as high as ten feet per minute—removes deposits from flinty hardness to soft gum as well as chemical compounds such as carbonates, sulphates, sulphites, silicates, chlorides, coke, marine growths and iron oxides.

In the range between 1/2" and 1 1/2", few jobs are too tough for the versatile and rugged PGX cleaner. The work is done by a long-wearing carbide cutter bit and a stream of air or water forced under high pressure through a hollow shaft and beyond the cutter tip. It flushes as it cuts—no need to worry about jammed, burned-out bits—no need for lengthy, expensive preliminary work to prepare the tube for cleaning.

Don't let valuable equipment stand idle for days while you struggle with inadequate cleaning tools. Put the pressure on with PGX.

Also ask about two teammates of the PGX—the PG for 1/2" to 1" ID and the TP 301 for 3/8" to 2" ID. All three models can be fitted with accessory expanding brushes and expanding scrapers. These and scores of other tube maintenance tools are described in the new, free Wilson Catalog 77. Write for it today.

Representatives in principal cities

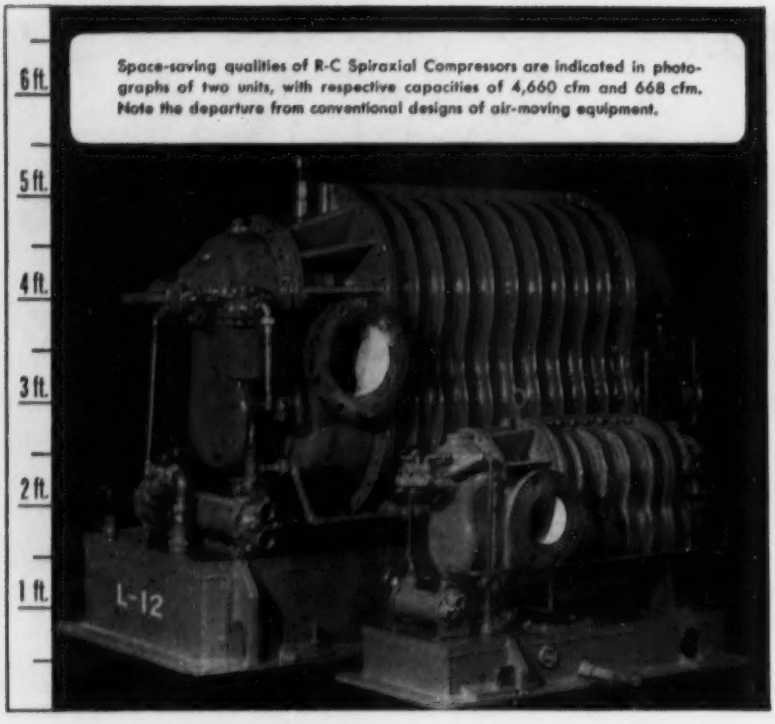
THOMAS C. WILSON, INC. • 21-11 44th Ave., Long Island City 1, N.Y.
Cable address: "Tubeclean", New York

WILSON

TW-852

TUBE CLEANERS • TUBE EXPANDERS

For more data on advertised products, use Readers' Service Cards, last page.



Space-saving qualities of R-C Spiraxial Compressors are indicated in photographs of two units, with respective capacities of 4,660 cfm and 668 cfm. Note the departure from conventional designs of air-moving equipment.

For intermediate pressures . . .

SEE R-C SPIRAXIAL® COMPRESSORS

Check these values of R-C Spiraxials before buying any equipment

1. **No internal lubrication —hence oil-free air.**
2. **Internal compression assures peak efficiencies at required pressures.**
3. **Direct connected for speeds of 1750 rpm and 3550 rpm.**
4. **Uncooled — requiring no water-jacketing.**
5. **Small space — low noise level.**

Before deciding on any air-handling equipment, see the new developments in R-C Spiraxial Compressors.

The amazing efficiency and economy of this latest Roots-Connersville development in air-handling equipment have been proved in continuing orders and installations.

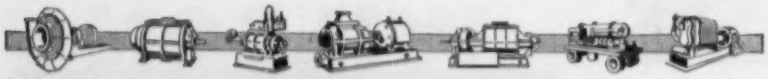
Bridging the gap between the R-C *dual-ability* lines of Centrifugals and Rotary Positives, Spiraxials provide a capacity range from 700 cfm to 5,000 cfm, with pressures from 15 psi to 30 psi. Either single-stage, or multi-stage installations for higher volumes, are completely satisfactory.

For new projects, we suggest a study of these newest Spiraxials. Or, it may well be that they will soon pay for themselves as replacements for present less efficient equipment. Ask for performance curves, and details in Bulletin SC-354.

ROOTS-CONNERSVILLE BLOWER

A DIVISION OF DRESSER INDUSTRIES, INC.

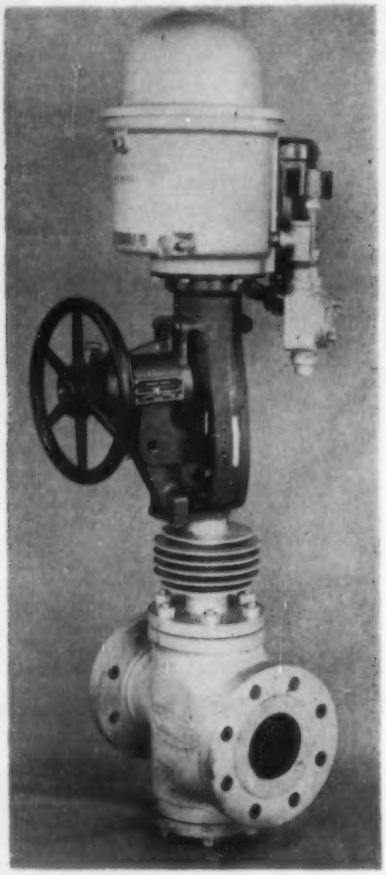
Roots-Connersville Blower (Canada) Ltd. • 629 Adelaide St. W., Toronto, Ont.



Centrifugal and Rotary Positive Blowers and Exhausters • Positive Displacement Meters • Vacuum Pumps • Gas Pumps • Inert Gas Generators • Spiraxial Compressors

New Equipment . . .

cally intended to complement the use of electronic process control instruments and makes available a completely integrated electrical process control system. Such a system is desirable where long transmission distances are involved, where freezing or clogging of pneumatic tubing is a problem and where electronic instrumentation has



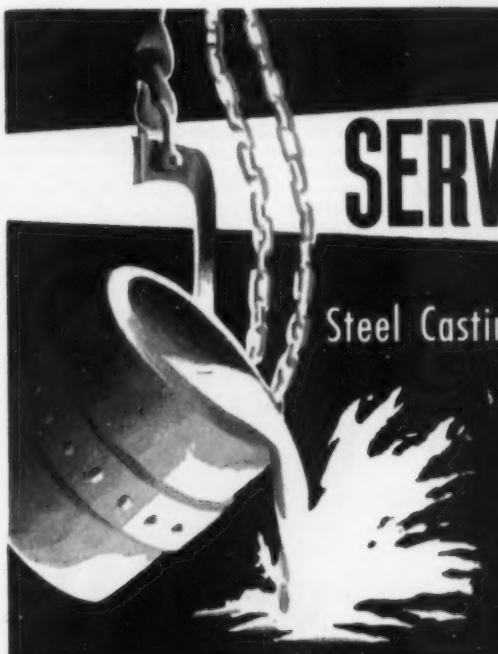
otherwise been selected for the application.

The unit is designed to position conventional slip-stem control valves and the operator uses hydraulic force developed by a self-contained pumping unit supplied by 115 or 230 volt electrical power. Incompressibility of the hydraulic fluid permits positive positioning of the valve against greatly varying stem thrust, thus overcoming valve flutter and accomplishing accurate control.

Positioning accuracy is established by a self-contained feedback system. The control valve operator accepts the 0.5 to 5.0 milliampere direct current signal transmission. Control signals may include proportioning, reset and rate actions for the purpose of controlling, ratioing, and programming. For further information on this new instrumentation device . . .

Circle E8 on Postcard

Pump Pulsation Absorber for The Yale & Towne Manufacturing Company's tri-rotor pump will reduce vibration by as much as 75 percent in both suction and



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cuts machine repair costs 80%—
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Rotor blades • Packing areas • Pump plungers

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Esso Standard Oil Co.
Gulf Oil Co.
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Phillips Petroleum Co.
Socony-Vacuum Oil Co.
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See our 8-page Bulletin in Sweet's File for Plant Engineers; or write

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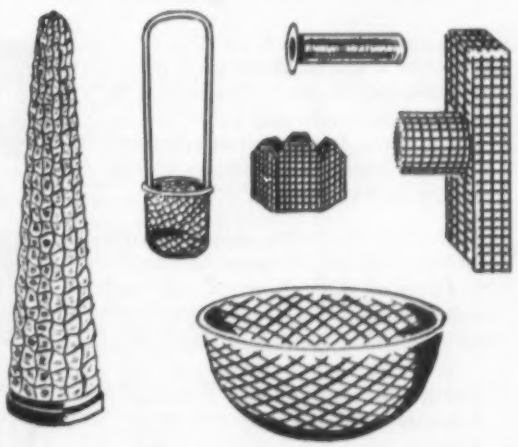

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Department 16

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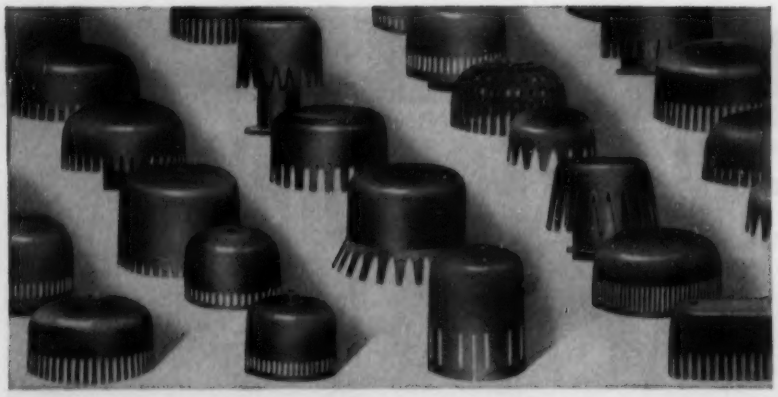

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This standard reference on bubble caps and risers contains complete specification information for hundreds of variations. Also many drawings for use in determining methods of tray assembly. With dies on hand for all listed styles, PSC can save you substantial die costs as well as design and delivery time. Furnished in any drawing type of metal, to meet your coking or corrosion problems. Assemblies will also be produced to your specifications.

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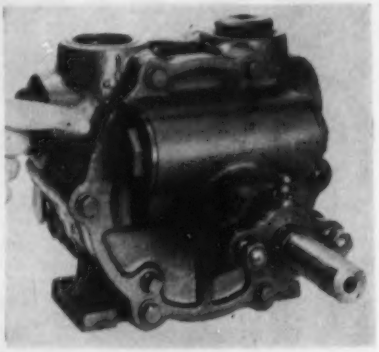
New Equipment . . .

discharge lines of the pump. The pulsation absorber is a simple piston device which equalizes pulse peaks in either the discharge or suction sides of Tri-Rotor pumps and make auxiliary dampeners or air chambers unnecessary.

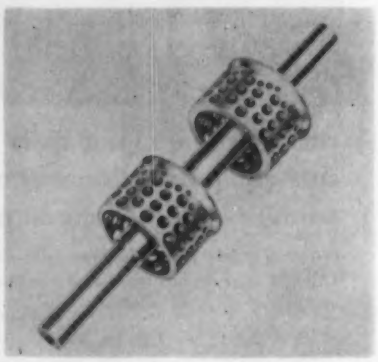
The piston is in a cylinder connected across the suction and discharge ports of the pump and within this cylinder is a light



plunger which operates against a heavy spring in the suction side of the cylinder, and a light spring in the discharge side.

When a pressure leak is produced at the discharge port by a pump impulse, the piston moves toward the suction side. This action relieves the pressure peak, and, at the same time, compensates for the corresponding suction increase which is developed at the pump intake. For information on this added auxiliary device . . .

Circle E9 on Postcard



Control Valve Plugs for use in applications where there is a flashing at the valve has been announced by Hammel-Dahl Company. This valve plug tends to eliminate the destructive vibration, trim deterioration, and high noise level which often occurs in valves on flashing liquid service. The Flash-Flow Plug design has threaded holes which are geometrically spaced around the plug skirt to create turbulence and distribute energy release over a large surface area. The Flash-Flow Plugs are available in sizes from 3 to 16 inches, with either single or double seated construction. For detailed information . . .

Circle E10 on Postcard

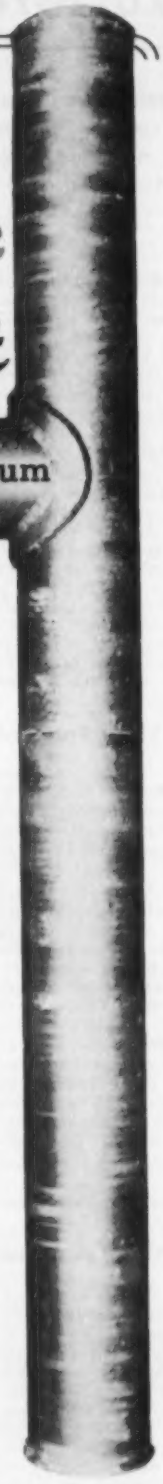
NO.2 in a series of ALUMICOAT APPLICATIONS

RESISTS HIGH TEMPERATURE CORROSION!

Alumicoat

Molten Aluminum

PROCESS PROTECTS REFINERY EQUIPMENT



More and more refineries are discovering the advantages of the new ALUMICOAT Process! ALUMICOAT offers a firm resistance against corrosive media — *especially sulphur compounds* — and extreme temperatures!

In the ALUMICOAT Process, refinery parts are dipped in molten aluminum to produce a metallurgical iron-aluminum bond at the interface and a surface overlay of pure aluminum. At temperatures exceeding the melting point of aluminum, the aluminum on the surface diffuses. This diffused coating, together with the iron-aluminum bond, provides a refractory material that gives steel maximum protection against high temperature scaling.

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Magnetrols are available for controlling level changes from .0025-in. to 150-ft., with single or multi-stage switching. Our experienced engineering staff is at your service.

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What's New in Manufacturers' Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Preparation of Petroleum Feeds for Platinum Catalysts is the title of a 12-page technical study just published by Minerals & Chemicals Corporation of America.

Discussion covers the effective reduction or removal of harmful constituents such as arsenic, lead, sulfur and nitrogen compounds by a specially processed group of the company's Attapulgus Clay products. Aspects of processing scheme, plant design, and clay description and costs are covered. Six tables and eight graphs present valuable supporting technical data. A free copy may be obtained if you will

Circle E11 on Postcard

A 3/4" rigid polyetheline faucet has been developed for use with the steel containers used in the refining, natural gasoline, petrochemical industries by Aurora Industries.

The white plastic faucets are leak proof, clean, and assure against product contamination by iron oxide. A quick, light-pressure finger twist opens or shuts the valve. The plastic connection gives a tight seal and non-drip operation.

Literature and samples are available now . . .

Circle E12 on Postcard

Automation, as it applies to the petroleum and chemical industries, is the subject of the current Kelloggram published by The M. W. Kellogg Company of New York. This literature contains diagrams throughout to illustrate clearly the basic functions of instruments used in automatic control. One section, for example, describes the use of radio-isotopes in level measuring devices, a relatively new development in the petroleum and petro-chemical industries. Another section discusses data reduction systems, with diagrams to show how automation depends on complete data reduction. Other subjects described are electronic instrumentation, stream analyzers and high pressure instruments.

For this discussion of automation as it is presently applied and a look at its future possibilities . . .

Circle E13 on Postcard

Insulation Data for a wide range of temperature problems are charted in a folder published by Mundet Corp Corporation. Also provided is brief descriptive information on materials available for high temperature applications, for intermediate temperature use, for hot- and cold-water and low-pressure steam, for ice water and frigid temperatures. For this concise and comprehensive bulletin, just . . .

Circle E14 on Postcard

Flareless Type Tube Fitting has been announced by The Parker Appliance Company and is being called the "Intru-lok" line. This fitting is designed especially for copper instrumentation lines where vibration resistance and economy of flareless assembly is desired. The tube is simply inserted through the nut and ferrule until it bottoms on the seat within the fitting body, and then the nut is tightened.

The wedging action of the nut causes the ferrule to "bite" into the outer surface of the tube wall, turning up a "shoulder" of metal to provide a leakproof, vibration-proof connection. This new fitting is available in all commonly used body shapes and in sizes ranging from 4 for tubing of 1/4 inch O.D. through 16 for 1 inch O.D. tubing. In addition, the Intru-lok line includes a specially designed nut and insert, in sizes 4 and 6, for connection of plastic tubing of 1/4 and 3/8 inch O.D. To get detailed catalog 4324 just . . .

Circle E15 on Postcard

A Raman Spectrometer that combines the latest improvements in Raman design with standard spectrometer components has been announced by The Perkin-Elmer Corporation.

Called the Model R, the instrument features a Toronto-type helical mercury arc excitation source and a coated optical system for transferring the Raman radiation from the sample tube to the monochromator. Dispersion system, wave length drive, detector and recorder are similar to the components used on standard Perkin-Elmer infrared spectormeters.

The unit operates through a frequency range of 100-3500 cm^{-1}. Survey spectra can be scanned in 12 minutes, while high resolution spectra requires 50 minutes for scanning period. Resolution is 5 cm^{-1} for survey work and 2-3 cm^{-1} on high resolution spectra.

For complete technical details on this new instrument, just . . .

Circle E16 on Postcard

Fin Tube Data has been published by the Griscom-Russell Company on its G-R G-Fin tube. G-Fin tubes, originated by Griscom-Russell more than 20 years ago, were first applied to the widely used G-R Twin G-Fin section, of which more than 70,000 units have been built for installations including a wide range of heating, cooling, condensing and heat transfer services. The bulletin fully explains the methods of manufacture of the tubes, and includes a tabulation of the many sizes of fins and tubes which are now available.

For your copy of this bulletin, just . . .

Circle E17 on Postcard

Control Valves have been covered extensively in the new Mason-Neilan bulletin just published. This comprehensive bulletin covers the entire line of equipment available from the Mason-Neilan Company. Included also is a technical data section on the basic factors involved in selecting and sizing valves.

This book is a must for the engineer using, maintaining or selecting control valves so get yours now . . .

Circle E18 on Postcard

Dual vane hydraulic pumps designed expressly to meet the special conditions of service encountered on mobile equipment applications are described in an illustrated bulletin just released by New York Air Brake Company.

The brochure includes comprehensive selection data, showing flow rates and horsepower input for four sizes at selected operating speeds. Photos and drawings illustrate the dual vane feature, cam ring design and other component parts.

To receive your copy of this bulletin, DP-320, just . . .

This item supplements New York Air Brake Company data on pages 157-164 of The Refinery Catalog, 22nd Edition.

Circle E19 on Postcard

Flocculating Agents . . . American Cyanamid Company has developed a new group of synthetic polymers which have the ability to agglomerate finely-divided solids in liquid suspensions, with resultant improvement in settling and filtration rates.

Aerofloc Reagents are large, complex molecules, which when added to aqueous suspensions, bond together the individual fine solid particles into flocs. These flocs settle more rapidly than unconsolidated particles leaving a clarified supernatant suitable for re-use or for discarding without creating a pollution problem.

Where suspended solids are removed by filtration, Aerofloc Reagents have improved filtration rates as much as 150 percent on various types of materials. For your copy of a brochure on Aerofloc Reagents, just . . .

Circle E20 on Postcard

Stepping Switches . . . A new four-page catalog describing a complete line of control components for industrial use is now being offered by Automatic Electric Sales Corporation. Equipment listed includes stepping switches, relays, and key switches. Descriptive matter covers the functions, specifications, and an illustration of each relay and switch. For your copy of Circular 1843 . . .

Circle E21 on Postcard

Advertisers in September Issue

A

*The Air Preheater Corp. 94
*Air Products, Inc. 23
*Airetool Manufacturing Co. 290
Alan Wood Steel Co. 102
Allied Chemical & Dye Corp. 39, 67, 124
*Allis-Chalmers Manufacturing Co. 11, 13
*Aluminum Company of America 47, 337, 415
American Bitumuls & Asphalt Co. 343
American Brass Co. 106
American Cyanamid Co.
Refinery Chemicals Dept. 9
American Hard Rubber Co. 346
*American Recording Chart Co. 384
American Steel & Wire Division
United States Steel Corp. 179
The Annin Co. 323
Ansul Chemical Co. 395
Armco Steel Corp. 88
*Armstrong Machine Works 393
Atlantic Refining Co. 20
*Aurora Pump Division
The New York Air Brake Co. 402b
Automatic Electric Co. 225
Avondale Marine Ways, Inc. 437a

B

*B-I-F Industries, Inc. 2
*The Babcock & Wilcox Co. 196-197
*The Babcock & Wilcox Co.
Tubular Products Division 51, 355
*Badger Manufacturing Co. 292, 293
*Bailey Meter Co. 387
Baker & Adamson Products
General Chemical Division
Allied Chemical & Dye Corp. 124
Baker & Co. 344
*Baldwin-Hill Co. 381
*Barco Manufacturing Co. 342
W. H. & L. D. Betz 339
*Bigelow-Liptak Corp. 385
Bingham Pump Co. 312
*Black, Sivalls & Bryson, Inc. 371
*Blaw-Knox Co. 383
Born Engineering Co. 83
Bonney Forge & Tool Works 327
*Bridgeport Brass Co. 347
The Bristol Co. 340, 341
Brown & Root, Inc. 307
*Brown Fintube Co. 82
*Buell Engineering Co. 426
Burgess-Manning Co. 396
*Byron Jackson Co. 291

C

*Calumet & Hecla, Inc. 35, 36
*G. O. Carlson, Inc. 215
*The Carpenter Steel Co. 71
Carter-Waters Corp. 420e
Casting Repair Service 390
Catalytic Construction Co. 17
*Catawissa Valve & Fittings Co. 374
The Chapman Valve Mfg. Co. 349
Chase Brass & Copper Co. 24
Chemical Construction Corp. 33
Chicago Bridge & Iron Co. 353
*Chicago-Wilcox Mfg. Co. 390a
*Chiksan Co. 213
*Childers Manufacturing Co. 92
Cities Service Co. 73
*Clark Bros. Co. 188, 189
Classified Advertising 423
Cleton, Ltd. 336
Cleveland Wire Cloth & Mfg. Co. 402a
Climax Molybdenum Co. 90-91
Columbia-Geneva Steel Division
United States Steel Corp. 45, 179, 330
*Commercial Iron Works 72
Conoflow Corp. 89
*The Cooper-Bessemer Corp. 204, 205
*Crane Co. 285
*Crane Packing Co. 295
*Crosby Steam Gage & Valve Co. 356-357
W. H. Curtin & Co. 392b

D

Davis Engineering Corp. 316
Davison Chemical Company
Division of W. R. Grace & Co. 95
*Dean Bros. Pumps, Inc. 322
De Laval Steam Turbine Co. 75
*Delta Engineering Sales Co. 406a
*M. H. Detrick Co. 103
*Dollinger Corp. 74
Dowell Incorporated 109
Downingtown Iron Works, Inc. 388
Dravo Corp. 431c
*Dresser Industries, Inc. 188, 189
The Ducon Co. 334
E. I. du Pont de Nemours & Co. 79, 112, 377-378

E

The Eagle-Picher Co. 76
*Eastern Industries, Inc. 223
Electric Steel Foundry Co. 315
Electronic Associates, Inc. 354
*Elliott Co. ..... I Cover and 101
Emsco Manufacturing Co. 311
*Engineers & Fabricators, Inc. 77
Enjay Co. 27
*Ernst Water Column & Gage Co. 392a
Ethyl Corp. 114-115

Continued on Page 442

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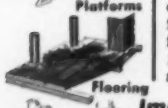
Work Platforms



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Important Safety Features

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★ Slip proof
★ Maximum strength
★ Minimum weight
★ Easy to stand on
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Big Economy Features

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★ No extra supports necessary—channels are integral part of the material
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★ Self-cleaning
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★ Low in original cost

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STAINLESS STEEL CYLINDERS
conform with ICC Regulations

Transport fixed or liquefied gases—even fluids corrosive to ordinary steels—in complete safety. Equally safe for pressure sampling under abnormally high temperatures.

Available for low or high pressure service, in single or double valve types. Sizes from 10 milliliters to 1 gallon. Standard sizes and types normally in stock—special cylinders available on order.

Wide selection of needle and packless valves for use with these cylinders.

Write for complete information

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Fluid Control Specialists
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Advertisers in September Issue

Continued from Page 441

F

Fenwal Incorporated 78
*Fisher Governor Co. 104-105
*Flexitallic Gasket Co. 299
Flexonics Corp. 430
*Flint Steel Corp. 370
*Floridin Co. 422
*The Fluor Corp. 199
*Food Machinery & Chemical Corp. 185
The Foxboro Co. 318
*Fram Corp. 350
Frick Co. 406b

G

*The Garlock Packing Co. 366
*General American Transportation Corp. 310
General Chemical Division
Allied Chemical & Dye Corp. 124
*General Electric Co. 37
General Metallizing & Machine Co. 394b
General Refractories Co. 367
Gilbert & Barker Mfg., Co. 81
The Girdler Co. 81, 319, 335
The Globe Co. 441
Claud S. Gordon Co. 386b
W. R. Grace & Co. 95
Graver Tank & Mfg. Co. 6
A. P. Green Fire Brick Co. 43
J. W. Greer Co. 85
The Emil Greiner Co. 187
*Grinnell Co. 289
*The Griscom-Russell Co. 84
The Gulf Publishing Co. 391, 410, 431d
Gunite Concrete & Const. Co. 420d
Gustin-Bacon Manufacturing Co. 63
Gutehoffnungshuette 433a

H

*Hamer Valves, Inc. 326
*Hammond Iron Works 46
The Harvey Line 394a
*Haynes Stellite Company
Div. Union Carbide and Carbon Corp. 407
Hercules Powder Co. 122
*Hewitt-Robins, Inc. 80
*Hoke Incorporated 441b
Hooker Electrochemical Co. 405
Houdry Process Corp. 308-309

I

*Ingersoll-Rand 42, 288
Insul-Mastic Corp. of America 403
The International Nickel Co. 399
*Irving Subway Grating Co. 386a

J

Jefferson Chemical Co. 119
*The C. O. Jelliff Mfg. Corp. 437c
*Jerguson Gage & Valve Co. 351
*Johns-Manville 183, 413
*Jones & Laughlin Steel Corp.
Supply Division 12

K

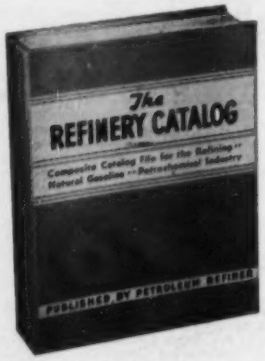
Kaiser Engineers
Division of Henry J. Kaiser Co. 401
Henry J. Kaiser Co. 401
*Keasbey & Mattison Co. 397
*The M. W. Kellogg Co. 296-297
C. M. Kemp Mfg. Co. 16
*Kerrigan Iron Works, Inc. 382
*Kewanee-Ross Corp. 86
*Key Co. 97
*Kieley & Mueller, Inc. 28
Kinney Manufacturing Division
The New York Air Brake Co. 380
*Richard Klinger, Ltd. 227

L

Leeds & Northrup Co. 8
*Warner Lewis Co. 350
Lukens Steel Co. 56
*The Lummus Co. 176, 177, 283

M

*Magnetrol, Inc. 439b
Maintenance Engineering Corp. 294
Manning, Maxwell & Moore, Inc. 93, 304, 305
Clayton Mark & Co. 404a
*Jas. P. Marsh Corp. 321
*Mason-Neilan Regulator Co. 22-23
The Master Electric Co. 358
*Arthur G. McKee & Co. 446
The Meriam Instrument Co. 338
Metallizing Engineering Co. 437b
*Metal Textile Corp. 331



*The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1955 Refinery Catalog.

*Milton Roy Co. 332, 333
*Mineral & Chemicals Corp. of America 315
W. K. Mitchell & Co. 87
*Mixing Equipment Co. 110
*Murray Iron Works Co. 412

N

*National Airoil Burner Co. 414
National Can Corp. 209
National Tube Division
United States Steel Corp. 179, 330
New England Tank & Tower Co. 416
*The New York Air Brake Co. 380, 402b
Nitrogen Division
Allied Chemical & Dye Corp. 39
*The C. W. Nofsinger Co. 418
*W. C. Norris Manufacturer, Inc. 303
*Norton Co. 30, 31

O

*Oakite Products, Inc. 61
*Oil Well Supply Division
United States Steel Corp. 7
*Orbit Valve Co. 317

P

Pacific Tube Co. 362
Palmer Thermometers, Inc. 352
The Ralph M. Parsons Co. 58
*Patent Chemicals, Inc. 373
Tod Paxdral Pipeline Specialties 348
*Peabody Engineering Corp. 389
*Peerless Manufacturing Co. 193
The Perkin-Elmer Corp. 428, 429
The Permutit Co. 438b
*Petreco
Division of Petrolite Corp. 54
*Petro-Chem Development Co. 343
Petroleum Electric Power Assoc. 363
*The Pfaudler Co. 409
*Phelps Dodge Copper Products Corp. 14-15
Phelps Dodge Refining Corp. 372
Philadelphia Gear Works, Inc. 57
*H. K. Porter Company, Inc. 96
*Posey Iron Works, Inc. 433b
The Wm. Powell Co. 26
Precision Thermometer & Instrument Co. 420f
*The Pressed Steel Co. 438a
J. F. Pritchard & Co. 207, 417
Procon Incorporated 65
*Proportioneers
Division of B-I-F Industries, Inc. ..... II Cover

Q

The Quaker Oats Co. 211
Quaker Rubber Corporation
Div. of H. K. Porter Co., Inc of Pittsburgh. 96

R

*The Refinery Catalog 360-361
The Refinery Engineering Co. 100
Geo. P. Reintjes Co. 420c
*Revere Copper and Brass, Inc. 281
Rheem Manufacturing Co. 419
The Ridge Tool Co. 314
*Rochester Manufacturing Co. 434
*Rockwell Manufacturing Co. 324-325
*Rockwell Spring & Axle Co. 398a
*Rockwood Sprinkler Co. 203, 411
*Roots-Connersville Blower Corp. 436
The Rowan Controller Co. 50

S

St. Mary Iron Works 431b
*Sarco Company ..... III Cover
*Scovill Manufacturing Co. 44
*Sealol Corp. 366
Selas Corp. of America 180, 181
Service Foundry Division
Avondale Marine Ways, Inc. 437a
Shand & Jurs Co. 40-41
Sheffield Steel
Division Armco Steel Corp. 88
Shell Development Co. 191
*Sillers Engineering Co.
Division Peerless Manufacturing Co. 193
*M. K. Skinner Co. 420b
Solvay Process Division
Allied Chemical & Dye Corp. 67
Southern Engine & Pump Co. 431a
Standard Oil Co. of California 369
*Standard Steel Spring Division
Rockwell Spring & Axle Co. 398a
Stauffer Chemical Co. 34
*Stone & Webster Engineering Corp. 69
*Strahman Valves, Inc. 398b
*Stratford Engineering Co. 375
*Strong, Carlisle & Hammond Co. 432
*Struthers Wells Corp. 59
Sun Engineering Co. 420a
*Sun Shipbuilding & Dry Dock Co. 70
Superior Electric Co. 49

T

*Taylor Instrument Companies 228-229
Tennessee Coal & Iron Division
United States Steel Corp. 45, 179
*The Terry Steam Turbine Co. 46
*Texas Metal Fabricating Co. 62
Arthur Tickle Engineering Works, Inc. 439a
The Timken Roller Bearing Co. 10
*Tretolite Co. 29-92
*Tubular Products Division
The Babcock & Wilcox Co. 51, 355
Tulsa Gauge & Instrument Co. 408b

U

*Union Asbestos & Rubber Co. 53
*Union Carbide and Carbon Corp. 407
United States Pipe & Foundry Co. 218, 219
*United States Rubber Co. 217
*United States Steel Corp. 7, 45, 179, 330
United States Steel Export Co. 45, 179, 330
United States Steel Supply Division
United States Steel Corp. 45, 179
*United States Stoneware Co. 21
Universal Oil Products Co. 98-99, 200-201

V

The Van Dorn Iron Works Co. 435a
Victor Products Corp. 408a
Visco Products Co. 286
*Henry Vogt Machine Co. 55
Vulcan Engineering Division
Vulcan Copper & Supply Co. 52

W

Walsh Refractories Corp. 60
Walworth Co. 195
Warren Petroleum Corp. 329
*Watson-Stillman Fittings Division
H. K. Porter Company, Inc. 320
West Instrument Corp. 404b
*Western Supply Co. 66
*Weston Electrical Instrument Corp. 64
Westvaco Mineral Products Division
Food Machinery & Chemical Corp. 185
A. R. Wilfley & Sons, Inc. 38
T. D. Williamson, Inc. 365
Thomas C. Wilson, Inc. 435b
*Wolverine Tube Division
Calumet & Hecla, Inc. 35, 36
*Worthington Corp. 68, 300, 301
Wyandotte Chemicals Corp. 421

Y

*Yarnall-Waring Co. 120
*Otto H. York Co. 359

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1	2	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
104	105	106	107	108	109	110	112	120	122	124	176	177	179	180	181	183	185	187	188
189	191	193	195	196	197	199	200	201	203	204	205	207	209	211	213	215	217	218	219
223	225	227	228	229	281	282	285	286	288	289	290	291	292	293	294	295	296	297	299
300	301	303	304	305	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321
322	323	324	325	326	327	329	330	331	332	333	334	335	336	337	338	339	340	341	342
343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362
363	365	366	367	368	369	370	371	372	373	374	375	377	378	380	381	382	383	384	385
386a	386b	387	388	389	390a	390b	391	392a	392b	393	394a	394b	395	396	397	398a	398b	399	401
402a	402b	403	404a	404b	405	406a	406b	407	408a	408b	409	410	411	412	413	414	415	416	417
418	419	420a	420b	420c	420d	420e	420f	421	422	426	427	428	429	430	431a	431b	431c	431d	432
433a	433b	434	435a	435b	436	437a	437b	437c	438a	438b	439a	439b	441a	441b	444	445	446		

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44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
104	105	106	107	108	109	110	112	120	122	124	176	177	179	180	181	183	185	187	188
189	191	193	195	196	197	199	200	201	203	204	205	207	209	211	213	215	217	218	219
223	225	227	228	229	281	283	285	286	288	289	290	291	292	293	294	295	296	297	299
300	301	303	304	305	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321
322	323	324	325	326	327	329	330	331	332	333	334	335	336	337	338	339	340	341	342
343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362
363	365	366	367	368	369	370	371	372	373	374	375	377	378	380	381	382	383	384	385
386a	386b	387	388	389	390a	390b	391	392a	392b	393	394a	394b	395	396	397	398a	398b	399	401
402a	402b	403	404a	404b	405	406a	406b	407	408a	408b	409	410	411	412	413	414	415	416	417
418	419	420a	420b	420c	420d	420e	420f	421	422	426	427	428	429	430	431a	431b	431c	431d	432
433a	433b	434	435a	435b	436	437a	437b	437c	438a	438b	439a	439b	441a	441b	444	445	446		

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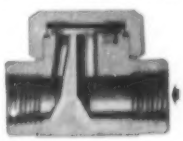

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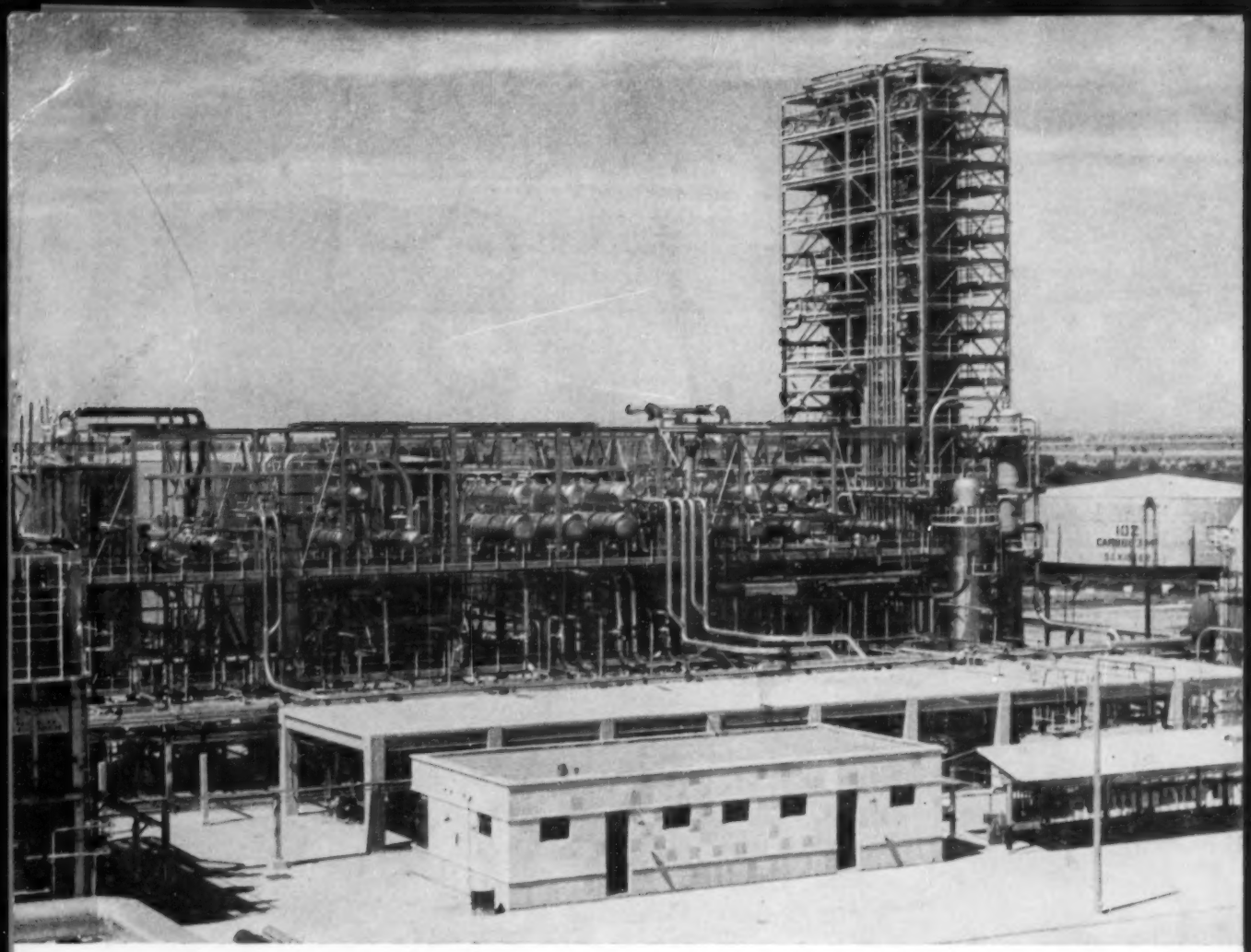

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